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**NSWCDD/MP-99/11**

# SYSTEMS ENGINEERING PLAN FOR SURFACE NAVY THEATER AIR DEFENSE (TAD)—VOLUME I: SYSTEM REQUIREMENTS ENGINEERING

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This plan for system requirements engineering defines the steps necessary to engineer Surface Navy Theater Air Defense (TAD) as a system. The high level architectures and requirements that result from this process are intended to guide future development priorities and road maps, describe functional allocation alternatives, and define interface controls required for safe and effective deployment of Surface Navy TAD.

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## FOREWORD

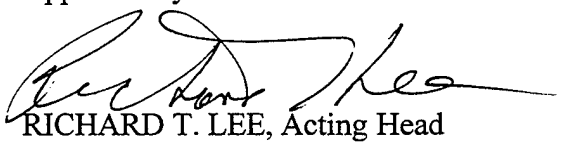
This plan for system requirements engineering defines the steps necessary to engineer Surface Navy Theater Air Defense (TAD) as a system. The high level architectures and requirements that result from this process are intended to guide future development priorities and road maps, describe functional allocation alternatives, and define interface controls required for safe and effective deployment of Surface Navy TAD.

System alternatives and upgrade priorities are established by economy of force for a reference mission and time period. Cost is balanced with performance in terms of defended volume, kill probabilities, and sustainability. The tenets of life cycle cost reduction, ease of upgrade, increased force interoperability, and TAD mission area optimization govern allocation of functions.

Success will require integration of the effects of many cross-functional teams instilled with a spirit of cooperation for benefit of the mission. These teams, empowered by Navy leadership and guided by engineering discipline, will construct the sail plan that unleashes the full potential of Surface Navy TAD systems.

This publication has been reviewed by Mr. E. R. Whalen, Head, Warfare Systems Division.

Approved by:



RICHARD T. LEE, Acting Head
Theater Warfare Systems Department

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# GLOSSARY

## 4.1 SURFACE NAVY TAD SYSTEM REQUIREMENTS ENGINEERING GLOSSARY

This glossary provides definitions of essential terms as used in the TAD System Requirements Engineering Plan. This glossary is an integral part of the TAD SEP and is to be used in the development of documentation called for in this document.

## 4.2 Definitions

**ALLOCATED BASELINE:** The approved documentation describing the Surface Navy TAD "System of System" sub-systems, (i.e. the nomenclatured system's functional, performance, interoperability, and interface requirements that are allocated from those of the higher level system), Surface Navy TAD. The Allocated Baseline will include the interface requirements with interfacing sub-systems; design constraints, derived requirements (functional and performance); and verification requirements and methods to demonstrate the achievement of those requirements and constraints. The Surface Navy TAD Allocated Baseline will be in the form of a System Requirements Document (SRD) for the Surface Navy TAD nomenclatured subsystems and will be the primary product of Step 4 of this plan. The SRDs will be the basis for the Program Manager's implementation of the nomenclatured systems.

**ATTRIBUTE:** Surface Navy TAD system characteristics which can be organized into various categories such as functions, constraints, performance parameters, cost, physical characteristics, supportability and availability.

**COMPOSITE FUNCTIONAL DESCRIPTION:** Hierarchical description of the functions to be performed by the future Surface Navy TAD system of systems required to meet the full set of Surface Navy TAD operational requirements. This functional model is developed from the functionality of current Surface Navy TAD systems and a functional decomposition of Surface Navy TAD related operational requirements.

**CONCEPTUAL PERFORMANCE BASELINE (CPB):** The documentation that identifies the Surface Navy TAD "System of Systems" performance concept chosen to meet the needs identified in the top level operational requirements documents. The Conceptual Performance Baseline includes broad objectives and thresholds for key cost, schedule and performance parameters, including supportability. Objectives will include thresholds identifying minimum acceptable requirements. The initial CPB will be the primary product of Step 3 of the system requirements engineering process described in this plan. Re-evaluation of alternative concepts or approaches will be performed if Step 4 of this plan determines that key parameters are not met.

**CONCEPT OF OPERATIONS (CONOPS):** A document that addresses the operational employment of a system(s).

**DESIGN REFERENCE MISSION (DRM):** A systems engineering approach which details the operational environment within which the Surface Navy TAD system attributes and requirement allocations are evaluated and used to evaluate the relative merit of proposed system concepts and upgrades for the TAD mission area. It defines the total envelope of the operational environments in which the Surface Navy TAD system must perform from the early stages of initial presence to the end of hostilities. The DRM is one of the key products.

**FUNCTIONAL BASELINE:** The approved documentation describing the Surface Navy TAD "System of System's" functional, performance, interoperability, interface requirements, and the verification required to demonstrate the achievement of those specified requirements. The basis for the Functional Baseline is the CPB defined in Step 3. The Functional Baseline is finalized in Step 4 of this plan.

**INTEGRATED PRODUCT TEAM:** Team composed of representatives from all appropriate functional disciplines working together with a Team Leader to build successful and balanced programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision-making.

**LIFE CYCLE COST ANALYSIS:** The identification, quantification, and qualification of LCC by segment with the purpose of establishing the cost interrelationships and the effect of each contributor to the total LCC.

**LIFE-CYCLE COST (LCC):** The sum total of the direct, indirect, non-recurring, and other related costs incurred, or estimated to be incurred, in the design, development, production (including manufacture and fabrication), acquisition, test and evaluation, acceptance, operation, maintenance, modernization, deactivation, and support of a configuration item over its anticipated life span.

**MEASURE OF EFFECTIVENESS (MOE):** Metric used to quantify a systems ability to meet its operational objectives. Examples of top level MOEs include probability of killing or countering a threat, system availability, defended area etc. Top Level MOEs may be decomposed into supporting MOEs. MOEs are typically evaluated for a specific or a series of operational situations or scenarios. MOEs are used to derive lower level technical performance requirements that are allocated to specific functions and subsystems.

**MIGRATION PATH:** A plan of actions and milestones required to reach the Surface Navy TAD FY 2015 baseline from the current Surface Navy TAD capability. The migration path is a major product of Step 4.

**MISSION SUCCESS CRITERIA:** Quantitative criteria to be used to assess if a ship, battle group, joint command, etc. will meet an assigned mission. The system being evaluated may be inherently involved in the mission or it may play only an enabling role. Examples might include such criteria as: (a) the battle group was able to successfully defend a specific area against ballistic missiles with a 99% probability of success, or (b) the task force was able to conduct sustained NGFS operations in the presence of hostile ASM engagements.

**OPERATIONAL REQUIREMENTS REVIEW:** The formal review of the results of Step 0 (Operational Needs and Requirements), Step 1 (Define the Operational Environment), and Step 2 (Define System Boundaries), of the Surface Navy TAD "System of Systems" engineering process.

**OPERATIONAL REQUIREMENTS TRACEABILITY MATRIX:** A matrix which traces operational requirements from the top level mission area down to the specific element/nomenclatured system. The matrix shows the decomposition and relationship of the operational requirements and is correlated with functional requirements.

**PERFORMANCE REQUIREMENT:** The extent to which a mission/operation or function must be executed, generally measured in terms of quantity, quality, coverage, timeliness, or readiness.

**QUALITY FUNCTIONAL DEPLOYMENT:** A structured process which provides an efficient and effective mechanism to decompose top-level system requirements into a prioritized set of lower level functional and design requirements.

**SURFACE NAVY THEATER AIR DEFENSE (SURFACE NAVY TAD) SYSTEM:** An integrated system which is comprised of all Surface Navy related Theater Air Defense resources and their interfaces with non-Surface Navy TAD and other Navy assets.

**SYSTEM OF SYSTEMS:** An integrated system comprised of a structural order of systems in which systems at any one level are embedded in successively higher level systems that address discrete operating tasks, mission areas, and ultimately joint operating forces. Specifically, Surface Navy TAD is comprised of all Surface Navy related Theater Air Defense resources and their interfaces with non-Surface Navy TAD and other Navy asset. This is a "system of systems" made up of various component systems. Similarly, the Surface Navy TAD "system of systems" is a subsystem of the broader Navy TAD, Joint TAD, and Theater Air Warfare "system of systems".

**SYSTEM REQUIREMENTS DOCUMENT:** A requirements document that translates operational requirements into functional, technical performance, interface, interoperability, and verification requirements and allocates those requirements to lower level subsystems. It defines the environment in which the system must operate as well as the threats the system must address.

**TAD SYSTEM REQUIREMENTS REVIEW (TSSR):** The final formal review and approval event conducted as Step 5 of the Surface Navy TAD System requirements engineering process.

# EXECUTIVE SUMMARY

Ref: (a) COMNAVSEASYSCOM Memo Ser TAD-SE 8003 of 10 Feb 97

Reference (a) established a pilot program for systems engineering in the Naval Sea Systems Command (NAVSEA) commencing with the Theater Air Defense (TAD) warfare mission area and assigned actions for the implementation of this pilot. PEO(TAD)-SE drafted Volume I of the Theater Air Defense Systems Engineering Plan which follows. This effort is needed due to the current lack of an integrated set of requirements that address each of the Surface Navy's Theater Air Defense mission areas. This effort is also driven by the constraining DOD budget to enable a performance/cost balanced optimization of the Surface Navy Theater Air Defense (Surface Navy TAD) system at the theater level. Volume II which details the remainder of the Surface Navy TAD system engineering efforts will be developed by the TAD mission program managers.

This system requirements engineering document provides detailed guidance for the execution of TAD system requirements engineering assessment, management and allocation activities at the "system of systems" level for Surface Navy TAD in the context of Joint Theater Warfare. The plan applies systems engineering principles, appropriately tailored, to determine performance, functional and interface requirements and the allocation of those requirements to individual Surface Navy TAD nomenclatured systems to:

- Create a "system of systems" for Surface Navy TAD that supports achievement of Joint Theater Air Warfare objectives while bringing cost, schedule and performance factors into balance at both ship and warfare area levels for the fleet of 2015.

The "system of systems" addressed by this plan comprises Surface Navy TAD in the context of Joint Theater Air Warfare. Figure 1-1 illustrates the scope of Surface Navy TAD in the larger system context. This plan addresses the system requirements engineering activities prior to Milestone II. A detailed Systems Engineering Management Plan (SEMP) will be prepared for each TAD subsystem to be followed in the execution of each subsystem's life-cycle. This plan is only a part of an overall systems engineering management plan that must be developed by each mission program. The non-Surface Navy TAD systems will be represented in this effort as top-level performance elements with their respective interfaces to Surface Navy TAD. Within Surface Navy TAD as shown in Figure 1-1, there are three levels:

- Multiple Surface Navy TAD Warfighter Mission Areas;
- TAD Acquisition Mission Programs headed by PEO(TAD); and
- Surface Warfare Product Programs (nomenclatured systems) of which only a few are shown.

It is the intent of this plan to describe the process for developing a Surface Navy TAD "system of systems" System Requirements Document (SRD) that addresses and allocates requirements for each of these levels. The objective is a performance, cost and schedule balanced set of requirements that enable the development of a Surface Navy TAD capability optimized at the theater level. It is recognized that many Surface Navy TAD system elements have a multiplicity of functions encompassing other warfare areas. However, the Surface Navy TAD functions will be the focus of this system requirements engineering effort with only limited attention given to non-Surface Navy TAD functionality.

EIA/IS- 632 Interim Standard Systems Engineering, DOD directives and DOD 5000.1 and 5000.2 series instructions were the cornerstones from which this system requirements engineering plan was developed. This plan provides the basis for scheduling, costing, tracking and controlling the PEO(TAD)-SE led system requirements engineering effort and will be the basis for comprehensive technical planning for the entire program. Commencing in October 1997, this plan governs an initial two-year system requirements engineering effort. After completion of the initial effort, annual updates will be conducted to incorporate lessons learned, new requirements and to provide training opportunities for systems engineers. Under the guidance of PEO(TAD) and PEO(TAD)-SE, the Surface Navy TAD Pre-Milestone II system requirements engineering activities will be jointly led by NSWCDD and the Johns Hopkins University Applied Physics Laboratory (JHU/APL) as the Systems Development Engineer and Systems Concept Engineer, respectively, and produce the:

- Surface Navy TAD Functional Baseline, Allocated Baseline and System Architecture;
- Final Surface Navy TAD SRD that defines performance, interface and functional requirements for the nomenclatured systems that are subsystems of the 2015 Surface Navy TAD "system of systems";
- Draft ORDs;
- Migration path from the current Surface Navy TAD System to the performance/cost/risk balanced system of the 2015 time frame;
- Non-Surface Navy TAD systems interface requirements recommendations;
- Technology development requirements;
- Risk Reduction Prioritization Report; and
- Design Reference Mission.

Work will begin with efforts to identify existing mission needs and to organize operational requirements pertaining to the Surface Navy TAD System, followed by analysis to define the 2015 era Design Reference Mission (DRM) from both Joint and U.S. Navy perspectives as determined by Defense Planning Guidance and the design-stressing aspects of the mission. The next steps will be to determine system boundaries and to determine key attributes of the 2015 era Surface Navy TAD System. A Conceptual Performance Baseline (CPB) will be developed that includes top-level functional and performance requirements for Surface Navy TAD.

A series of assessments will then be conducted to determine current* system capabilities and to evaluate candidate improvements stressing performance and life cycle cost at the Warfare Area level. Assessments will be conducted at the theater level to provide the following results:

- Determine current and in-development Surface Navy TAD performance and operational deficiencies;
- Determine Surface Navy TAD performance and functional requirements for candidate system enhancements and/or new developments in the form of a System Requirement Document that addresses each Surface Navy TAD subsystem (nomenclatured system);
- Determine poor performance and cost elements as candidates for termination; and
- Define the migration plan from the current Surface Navy TAD System to the performance/cost balanced system of the 2015 time frame.

* In the context of this plan, the term "current" includes near term and POM funded programs that are ongoing or will commence during this system requirements engineering effort.

Alternative system concepts will be refined throughout the assessment process to provide the best possible basis for final system baseline definition. An SRD, integration strategies and migration paths will then be prepared as appropriate to support a TAD System Requirements Review (TSRR). The focus of this plan is on pre-Milestone II aspects of the future Surface Navy TAD system, including major baseline upgrades. This effort will also address improvements to current systems as well as paring of systems due to cost/performance shortfalls.

The system requirements engineering process defined in this plan is a six (6) step process which was uniquely tailored from classic systems engineering principles. This six step process is shown in Figure 1-2 and is discussed in detail in Section II of the plan. A brief description of each step is provided below:

- Step 0: Identify Operational Needs and Requirements

  The purpose of this step in the system requirements engineering process is to collate and reconcile the operational requirements and needs for the existing systems that are considered within the scope of the Surface Navy TAD System. Since many of the operational requirements are not clearly defined for the Surface Navy TAD "system of systems" it is important to have an understanding of the legacy requirements. The purpose of this step in the System Engineering Process is to collate and reconcile the operational requirements and needs for the existing systems that are considered within the scope of the Surface Navy Theater Air Defense (SNTAD) system. Since many of the operational requirements are not clearly defined for the SNTAD system of systems it is important to have an understanding of the legacy requirements.

- Step 1: Define the Operational Environment

  The purpose of this step is to define the Surface Navy TAD 2015 Design Reference Mission which details the operational environment within which the system attributes and requirement allocations are evaluated. Accurate and complete specification of the DRM is required to support the evaluation of allocation alternatives and to communicate to the Surface Navy TAD design team the relative importance of design characteristics. The DRM will be the baseline used to evaluate the relative merit of proposed system concepts and upgrades for the TAD mission area.

- Step 2: Define the System's Boundaries

  The intent of this step in the Surface Navy TAD system requirements engineering process is to describe the functions, boundaries and interrelationships of the subsystems (or elements) that make up Surface Navy Theater Air Defense. This description will be developed in the context of Joint Theater Air Warfare. It will address the boundaries with overall Joint Theater Air Warfare and will document the sensitivity of current Surface Navy TAD performance to external interfaces and information flow.

- Step 3: Identify TAD System/Subsystem Key Attributes

  The objective of this step is to identify the key 2015 Surface Navy Theater Air Defense system and subsystem attributes that are fundamental to the successful completion of the Surface Navy TAD mission and to translate these findings into a Conceptual Performance Baseline comprised of top-level functional and performance requirements for Surface Navy TAD.

- Step 4: Establish the Surface Navy TAD Functional/Allocated Baseline

  The purpose of this step in the process is to establish the Surface Navy TAD Functional Baseline (performance, functional, physical) and allocate this baseline to existing and proposed nomenclatured subsystems for the Surface Navy TAD System circa 2015. This step will also define the migration plan to achieve this Allocated Baseline. The Allocated Baseline is in the form of a System Requirements Document which will be the basis for respective Program Offices to develop and field their combat system products.

- Step 5: Conduct a TAD System Requirements Review

  The Surface Navy Theater Air Defense system requirements engineering process culminates with the TAD System Requirements Review during which the Surface Navy TAD baseline, migration path, non-Surface Navy TAD requirements recommendations, technology development requirements and supporting analysis reports are presented to the Navy's senior leadership for concurrence, transition to Program Managers (PM's) for execution and Program Objectives Memorandum (POM) planning input.

Out to the mid-term future, the initial template for out future force will be "Joint Vision 2010." It is built on an integrated "system of systems" that aims to give our forces total battlespace awareness, as well as the capability to maneuver and engage the enemy at the time and places of our choosing throughout the entire battlespace.

# OVERVIEW

## 1.1 INTRODUCTION

PEO(TAD)-SE drafted Volume I: System Requirements Engineering of the Systems Engineering Plan (SEP) for the Theater Air Defense (TAD) warfare mission area. Volume I describes the system requirements engineering process to be followed in defining requirements for TAD capabilities for Navy surface ships. This document represents the initial portion of the systems engineering process. A Volume II, which details the remainder of the Surface Navy TAD systems engineering efforts, will be developed by the TAD mission program managers. To put the effort represented by this document in the proper context, there must be a common understanding of a systems engineering process. EIA/IS-632, DOD directives and DOD 5000.1 and 5000.2 series instructions were the cornerstones from which this System Requirements Engineering document was developed. The plan described in this document provides the basis for scheduling, costing, tracking, and controlling the system requirements engineering effort. This effort is needed due to the current lack of an integrated set of requirements for each of the Surface Navy's TAD mission areas. This effort is also driven by the constraining DOD budget to enable a performance/cost balanced optimization of the Surface Navy TAD System at the theater level.

## 1.2 PURPOSE

In general, the purpose of implementing a systems engineering process is threefold:

- To ensure all system requirements, specified or derived, are incorporated into the system design and are verifiable;
- To optimize the development process for the product to be provided for the warfighter by maintaining a traceable, integrated baseline; and
- To readily allow assessment of overall design maturity and risk during the decision making process to avoid costly downstream design and cost or schedule changes.

This volume of the system requirements engineering plan partially addresses the above general purposes and is focused on providing detailed guidance for the execution of a TAD system requirements engineering assessment, management and allocation activities at the "system of systems" level for Surface Navy TAD in the context of Joint Theater Warfare. The plan applies systems engineering principles, appropriately tailored, to determine performance, functional and interface requirements and the allocation of those requirements to individual Surface Navy TAD nomenclatured systems to:

- Create a "system of systems" for Surface Navy TAD that supports achievement of Joint Theater Air Warfare objectives while bringing cost, schedule, and performance factors into balance at both ship and warfare area levels for the fleet of 2015.

This plan defines the process to be used in establishing requirements for individual Surface Navy TAD systems to ensure that they support overall TAD requirements. This plan addresses the system requirements engineering activities prior to Milestone II. The processes addressed in

this plan are part of an overall PEO(TAD)-SE systems engineering thrust which also calls for increased systems engineering rigor at the mission area and individual nomenclatured system levels. This plan does not explicitly address the systems engineering processes to be used by individual Surface Navy TAD subsystems (i.e, nomenclatured systems) once functional, performance, interface and interoperability requirements have been established by the system requirements engineering effort defined in this plan. A detailed System Engineering Management Plan (SEMP) will be prepared for each TAD subsystem that will guide the detailed development and life-cycle support for that subsystem. Volume I is only part of an overall systems engineering management plan that must be developed by each mission program.

## 1.3 SCOPE

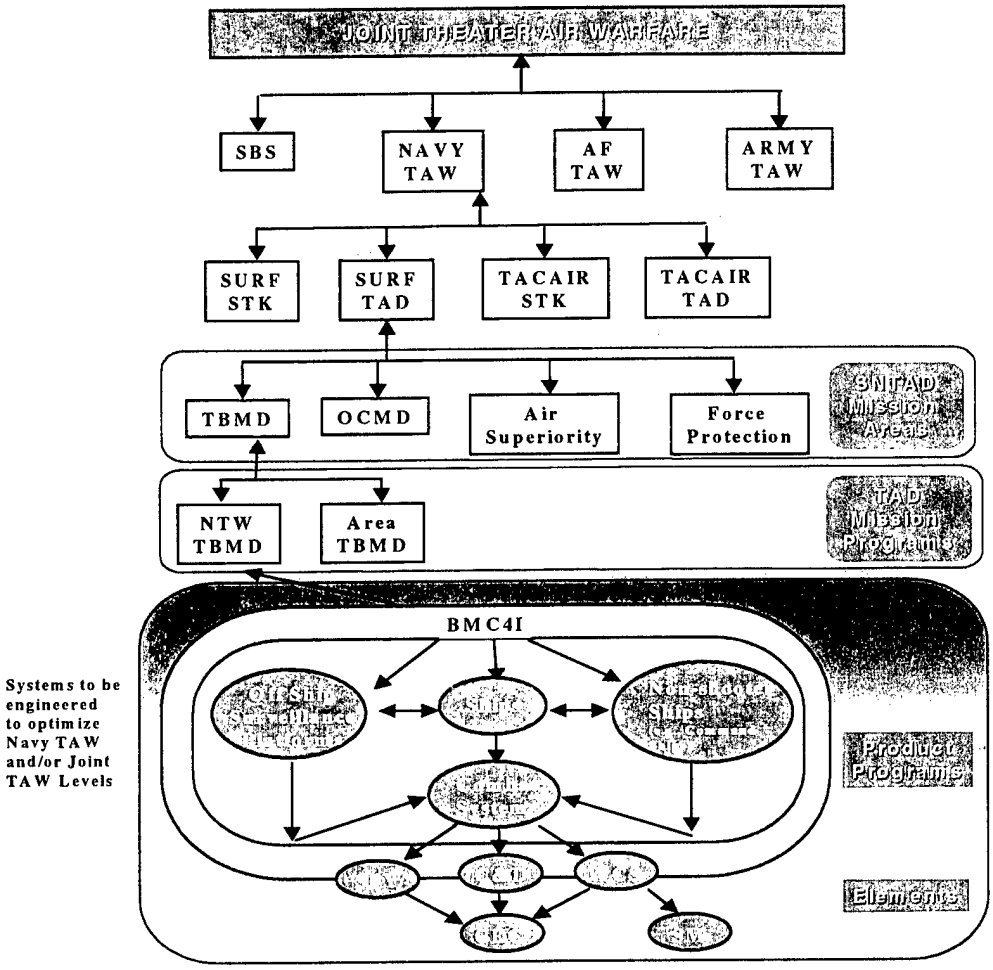
The "system of systems" addressed by this plan comprises Surface Navy TAD in the context of Joint Theater Air Warfare. Figure 1-1 illustrates the scope of Surface Navy TAD in the larger system context. The product programs in the bottom line of Figure 1-1, i.e., AWS, SM, CEC are systems or elements of systems, which can be employed to perform TAD today and provide a baseline from which future systems can be built to perform future Surface Navy TAD The non-Surface Navy TAD systems will be represented in this effort as top-level performance elements with their respective interfaces to Surface Navy TAD. Within Surface Navy TAD, as shown in Figure 1-1, there are three levels:

- Multiple Surface Navy TAD Warfighter Mission Areas;
- TAD Mission Acquisition Programs headed by PEO(TAD); and
- Surface Warfare Product Programs and their nomenclatured systems of which only a few are shown.

One intent of this Plan is to define the process for developing a Surface Navy TAD "system of systems" System Requirements Document (SRD) that addresses and allocates requirements for each of these levels. The objective is a performance, cost and schedule balanced set of requirements that enable the development of a Surface Navy TAD capability optimized at the theater level.

It is recognized that many Surface Navy TAD system elements have a multiplicity of functions encompassing other warfare areas. However, the Surface Navy TAD functions will be the focus of this system requirements engineering effort with only limited attention to non-Surface Navy TAD functionality.

For a large composite system, dealing with component systems one by one is not good enough. A new approach is needed, one that permits coordination of many independent projects to create a fully integrated "system of systems." The basic idea is that TAD systems engineering involves a hierarchy of design levels, and that systems at any one level are embedded in successively higher level systems that address discrete operating tasks, mission areas, and ultimately joint operating forces. A "system of systems" is produced by combining various component systems, each a product in its own right and with its own development sites, objectives, management, and schedule.




Note: Only the TBMD mission area is fully illustrated here for conciseness

Figure 1-1. Scope of Surface Navy TAD

The common system requirements engineering process, which is composed of Steps 0 through 5 is illustrated in Figure 1-2. This common process has been tailored for Surface Navy TAD system requirements engineering which will be discussed in detail in Section II.

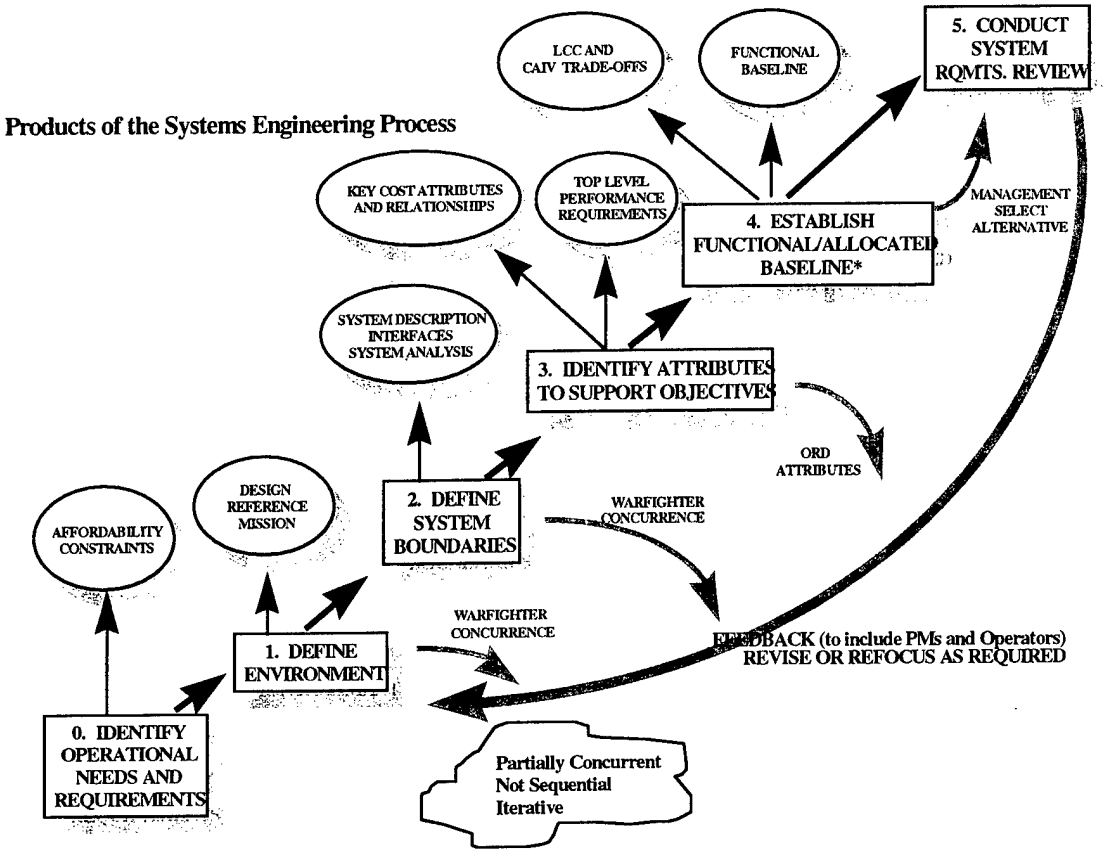



Figure 1-2. (TAD)-SE Common System Requirements Engineering Process

Work is expected to begin with efforts to identify and organize existing mission needs and operational requirements pertaining to the Surface Navy TAD System. The 2015 Design Reference Mission (DRM) will then be defined from both Navy and Joint perspectives and will be based on Defense Planning Guidance and consideration of design stressing aspects of the mission. Steps will then be taken to determine system boundaries and key attributes of the 2015 era Surface Navy TAD System. A Conceptual Performance Baseline will be developed that includes top-level functional and performance requirements for Surface Navy TAD.

A series of assessments will then be conducted to determine "current" system capabilities and evaluate candidate improvements stressing performance and life cycle cost at the Battle Force level. Assessments will be conducted at the theater level to provide the following results.

- Determine current**, including in-development, Surface Navy TAD performance and operational deficiencies;

- Determine Surface Navy TAD cost balanced performance and functional requirements for candidate system enhancements and/or new developments in the form of a System Requirements Document (SRD) that addresses each Surface Navy TAD subsystem (nomenclatured system);
- Determine poor performance and cost elements as candidates for termination; and
- Define the migration path from the current Surface Navy TAD system to the performance/cost balanced system of the 2015 time frame.

Alternative system concepts will be refined throughout the assessment process to provide the best possible basis for final system baseline definition. A Systems Requirement Document (SRD) and migration paths will then be prepared as appropriate to support a TAD System Requirements Review (TSRR). The focus of this plan is on pre-Milestone II aspects of the future Surface Navy TAD System, including major baseline upgrades. This effort will also address improvements to current systems as well as paring of systems due to cost/performance shortfalls. The Surface Navy TAD SRD will be the basis for the Program Managers' development of the mission programs and Surface Navy TAD subsystems which for the first time will be based on optimizing theater level performance.

Figure 1-3 shows the relationship of the Surface Navy TAD SRD to the warfighter generated Top Level Operational Requirements and to the individual program Top Level Requirements (TLRs) and specifications. In addition to the Surface Navy TAD SRD, the system requirements engineering process will produce draft ORDs where the Top Level Operational Requirements are incomplete or not formally stated. The figure also illustrates that many of the systems involved in this process have requirements that come from non-Surface Navy TAD missions.

Figure 1-4 illustrates the relationship of the system requirements engineering process described in this plan to the general acquisition milestones and the remainder of the system development process. This system requirements engineering process will determine the Surface Navy TAD Conceptual Performance, Functional and Allocated "system of system" baselines. The mission and product program managers are responsible for taking the allocated requirements and developing the individual systems which constitute the Surface Navy TAD "system of systems". The mission and product program managers will be responsible for establishing processes in their individual SEMPs to maintain traceability to the Surface Navy TAD requirements. Since the Surface Navy TAD system requirements engineering process will only generate a top or first level allocation, additional iterations of the system engineering process are performed by the program managers to define the lower level allocated and product baselines. These product baselines will be used for the actual development of the equipment and computer programs.

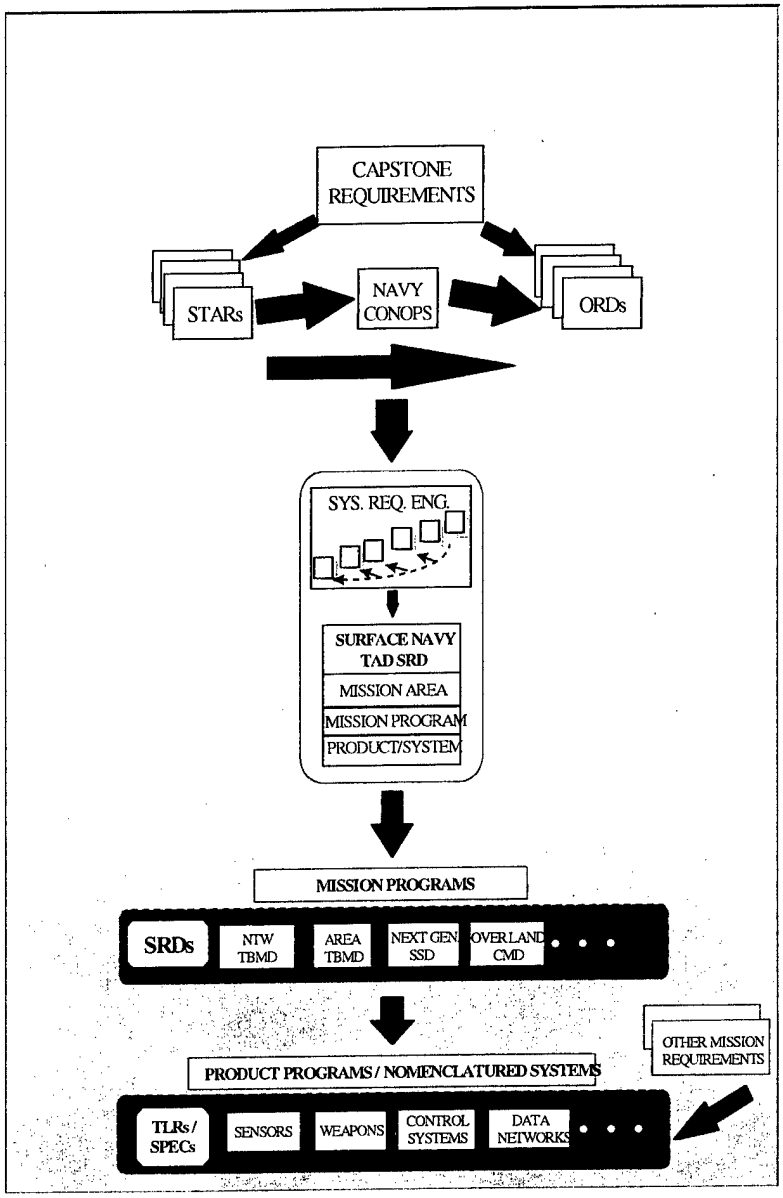



Figure 1-3. Surface Navy TAD System Requirements Engineering Document Framework

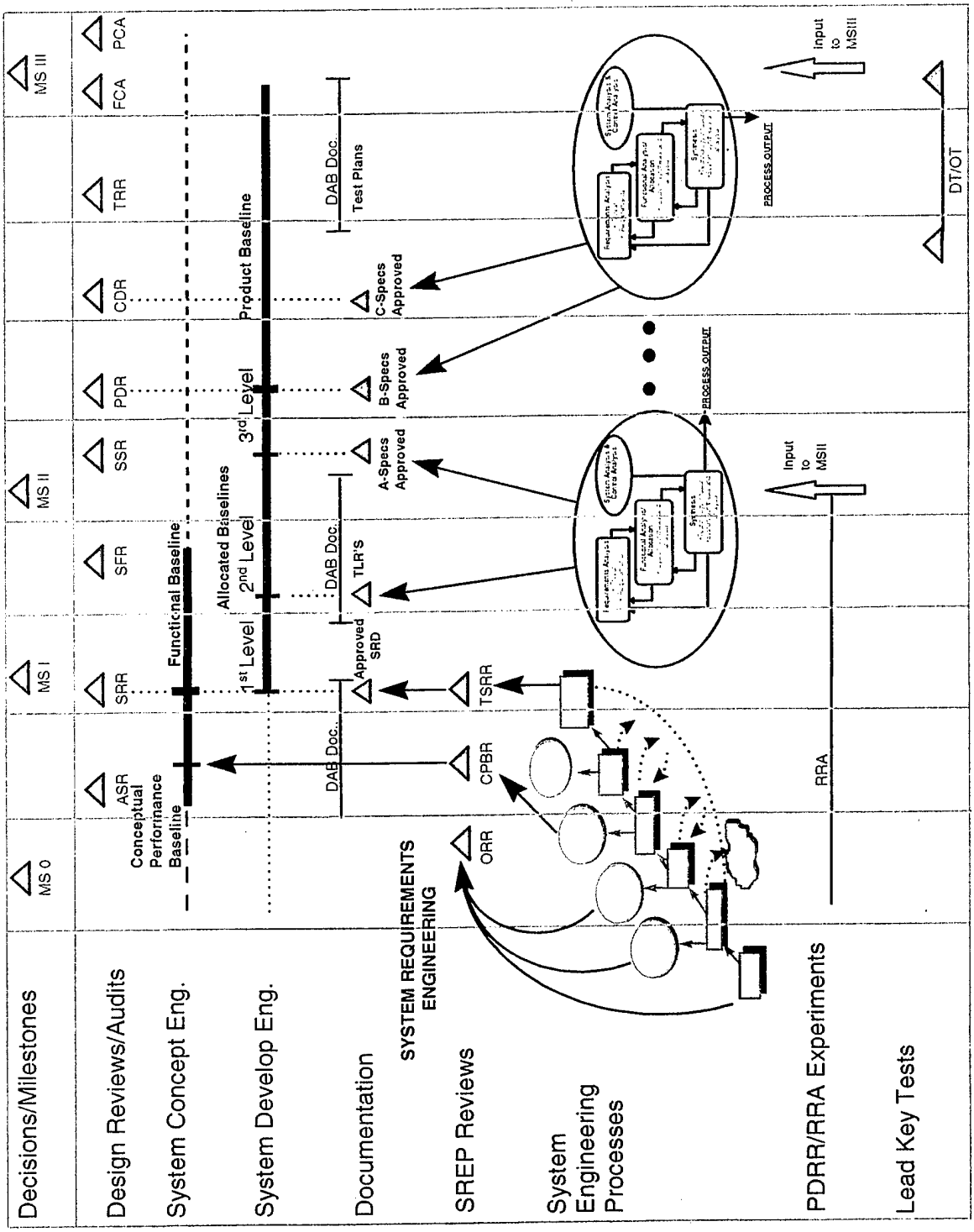



Figure 1-4. Relationship of Surface Navy TAD System Requirements Engineering to Acquisition Milestones

## 1.4 TECHNICAL PROGRAM MANAGEMENT (PM) AND CONTROL

Management and control activities are intended for directing, tracking, and reviewing program accomplishments, results, and risks against documented estimates, commitments, and plans. Appropriate corrective actions can then be taken when performance deviates significantly from plans.

### 1.4.1 General Systems Engineering Roles and Responsibilities

The general system requirements engineering roles and responsibilities are taken from the 16 June 97 draft PEO TAD guidance and policy paper on TAD systems engineering roles and responsibilities. The significant investment in people and facilities necessary to execute each phase of the system requirements engineering process requires organizational focus and commitment for proper execution. The need to develop solutions that optimize cost and effectiveness at the TAD mission level of system make it necessary to establish a more formal and enduring structure for the execution of systems engineering. PEO TAD has assigned the following roles and responsibilities for Navy TAD systems engineering. Leadership roles do not imply exclusive dominance.

#### 1.4.1.1 TAD Systems Engineer

The PEO TAD Systems Engineer, TAD-SE, is responsible to the PEO for the technical and system architecture of all TAD systems. TAD-SE defines the system engineering process that TAD programs will follow and provides budget inputs to PMs for implementation of that defined system engineering process. Important to this process is allocation of functions to systems and components for PM implementation. TAD-SE will direct the PEO systems engineering processes, including those at Johns Hopkins University/Applied Physics Laboratory (JHU/APL) and Naval Surface Warfare Center, Dahlgren Division (NSWCDD). TAD-SE is charged with supporting PMs in the overall implementation of systems engineering.

#### 1.4.1.2 Systems Concept Engineer

The (JHU/APL) is assigned the role of PEO TAD Conceptual Systems Engineer. In this role, JHU/APL shall develop system concepts, with risk reduction approaches including prototyping as necessary, for all TAD systems and major upgrades. These concepts shall be formulated into a Conceptual Performance Baseline which will be the basis for Functional Baselines for TAD systems. JHU/APL shall certify to PEO TAD that the Conceptual Performance Baseline and its functional allocation satisfies the mission need with a design that is balanced in performance, cost and schedule. JHU/APL shall continue to monitor the development to assure that the integrity of the concept and its performance is maintained as the development matures. JHU/APL will have a supporting role in the development of Allocated Baselines. The objectivity necessary to carry out this role precludes assignment of design agent functions to the system concept engineer except under special circumstances approved by the PEO.

#### 1.4.1.3 Systems Development Engineer

The (NSWCDD) is assigned the role of PEO TAD Systems Development Engineer. NSWCDD has the responsibility to accept the Functional Baseline for the Program Manager. Acceptance of the Functional Baseline shall include the verification that the Functional Baseline meets the requirements for all TAD systems and major upgrades. NSWCDD is responsible for certifying to PEO TAD that the Functional Baseline is consistent with the approved Conceptual Performance Baseline and satisfies the mission need with a design that is balanced in cost and performance for the specified need date. As the Systems Development Engineer, NSWCDD has lead government responsibility for the development of the Allocated Baseline for all TAD systems and major upgrades. NSWCDD has lead responsibility for government oversight deemed necessary by the PM for government acceptance of the product baseline. In this

capacity, NSWCDD is responsible for certifying to the PEO that the Allocated Baseline fully implements the requirements of the Functional Baseline and satisfies mission need while maintaining cost and performance balance and schedule. NSWCDD will have a major supporting role in the development of new system concepts and technologies, as well as a supporting role in the development of the Conceptual Performance and Functional Baselines.

#### 1.4.1.4 TAD PMs

Individual PMs are responsible for planning and budgeting all phases of engineering. The assigned TAD Systems Engineer is responsible to the PM for performance, cost and schedule management of systems engineering and to TAD-SE for compliance with technical policy and requirements. The PM is responsible for the technical integrity of the system throughout the system life, for selection between technically acceptable design alternatives and determination of the degree of acceptable risk. PMs are encouraged to identify and implement specific system engineering taskings in concert with this policy.

### 1.4.2 Management Structure for Plan Implementation

A high-level diagram of the management structure for execution of these system requirements engineering activities is shown in Figure 1-5. DOD guide to Integrated Product/Process Development (IPPD) (Version 1.0) and responsibilities for the step Work Groups are defined in the respective section for each step.

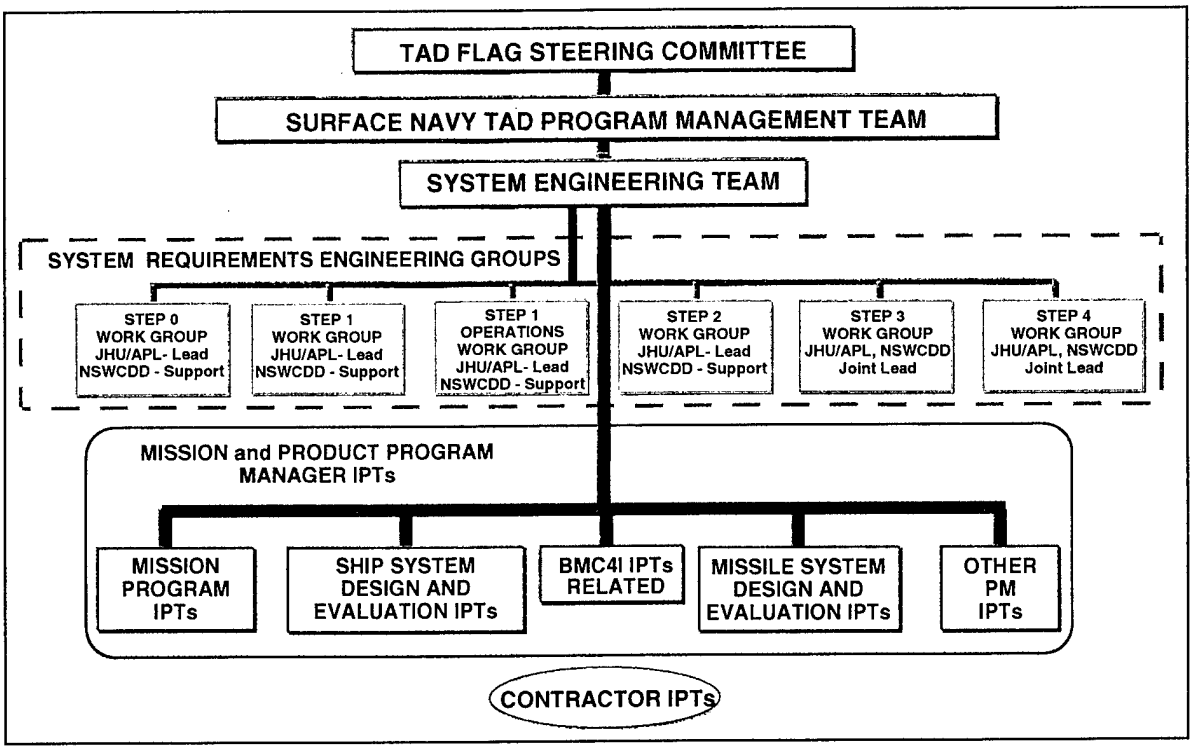



Figure 1-5. SEP Management Structure for System Requirements Engineering Execution

1.4.2.1 TAD Flag Steering Committee

A TAD Flag Steering Committee will be formed to guide the execution of this plan. PEO(TAD) will chair the TAD Flag Steering Committee with membership to include the following:

- PEO CLA
- PEO SC
- SPAWAR
- NAVAIR
- NAVSEA 05 (CWSE)
- CN0 N86
- CN0 N6
- CN0 N4
- CNO N88
- DASNC4I
- JTAMDO
- NSWC
- NDC
- PEO(TAD)-SE
- BMDO
- CNO N85
- NAVSEA 03 (CSSE)

This Flag Steering Committee will adjudicate the recommendations of the Systems Engineering Team and subservient step work groups.

1.4.2.2 Surface Navy TAD PMT

For each mission area/program in PEO(TAD), a PMT will be created to assist the Program Manager for a given mission area/program to manage the efforts with which the PMT is charged. The chairperson for this PMT will be the primary decision maker for actions that the PM is chartered to accomplish. Members of this PMT that will advise the PM will typically be:

- Deputy PM
- TAD SE representative
- PMS 422 representative
- PMS 410 representative
- PEO SC representative
- PEO CLA representative
- JHU/APL representative
- NSWCDD representative
- OPNAV representative

The specific tasks that the PMT will be chartered to perform are:

- Provide Plans and direction
- Provides funding
- Provides conflict resolution
- Conducts independent reviews
- Provides program assessment
- Provides DAB coordination (if required)
- Provides DAB documentation approval (if required)

1.4.2.3 System Engineering Team

A (SET) will be formed which will be responsible for the allocation and management of cost and schedule milestones and exit criterion to the System Concept Engineer and System Development Engineer based upon the agreed allocations from the program managers. The Mission Area/Product System Engineer (SE) (who is matrixed to the TAD SE organization) will chair the SET with members from all contributing organizations as members. Typically, the membership would include:

- Mission Area Engineers
- PMS 422 SE
- PMS 410 SE
- PEO SC SE
- PEO CLA SE
- NSWCDD SE representative
- JHU/APL SE representative
- MIT/LL representative
- SE&I contractor representative
- System Design Contractor representative

Some of the tasks that the SET would be chartered to perform, but not limited to are:

- Coordinate development, review and approval of:
  - ORD and SRD;
  - SEMP;
  - Mission requirements and design;
  - Risk reduction; and
  - System Design Reviews.
- Provide:
  - Program integration;
  - Ship combat system engineering input;
  - DAB support;
  - Technology transition plan; and
  - Coordination with external organization functions.

PEO(TAD)-SE will chair the SET with NSWCDD and JHU/APL as principal members. Other membership may be included as appropriate.

1.4.2.4 Mission and Product IPTs

Depending upon the specific situation, each SET will charter a number of mission or product IPTs that will be charged with the responsibility of managing the development of its specific area. These areas might include ship combat system engineering design, BMC4I, missile system design, threat definition or T&E. These IPTs would be chaired by Mission or Product SEs and would typically include the following members:

- PMS 422
- PMS 410
- PEO SC
- JHU/APL
- NSWCDD
- MIT/LL
- Mission Area engineer
- SE&I contractor
- System design contractor representative

Some of the tasks that these IPTs would be chartered to perform, but not limited to, are:

- Coordinate development, review and approval of:
  - Ship system engineering (including all subsystem elements, i.e., combat system, BMC4I, etc.)
  - Threat definition
  - TEMP
  - Flight test plans
  - Failure analyses
  - TLRs
  - PIDS
  - CM plan for a CI

1.4.2.5 PMs - Plan Execution Responsibilities

Program Managers support the system requirements engineering process as addressed in 1.4.1.4. The PMs and their system engineers support this system requirements engineering process as follows:

- Be a member of the Surface Navy TAD Program Management Team;
- Be a member of the System Engineering Team;
- Be a member of the Review Panel at ORR, CPBR and TSRR;
- Be a member of the Step 0 Work Group;
- Be a member of the Step 1 Engineering Work Group;
- Be a member of the Step 2 Work Group;
- Be a member of the Step 3 Work Group; and
- Be a member of the Step 4 Work Group.

1.4.2.6 PEO(TAD) Systems Engineer - Plan Execution Responsibilities

The PEO(TAD) Systems Engineer, PEO(TAD)-SE, has the general systems engineering responsibilities discussed in 1.3.1.1. The PEO(TAD)-SE responsibilities for the execution of this plan are as follows:

- Be a member of the Surface Navy TAD Program Management Team;
- Be responsible for the funding, direction and execution of the system requirements engineering activities;
- Chairs the Operational Requirements Review, (ORR), Conceptual Performance Baseline Review (CPBR) and TAD System Requirements Review (TSRR);
- Chairs the System Engineering Team; and
- Leads reviews to the Flag Steering Committee (Chaired by PEO(TAD)).

1.4.2.7 The JHU/APL - Plan Execution Responsibilities

JHU/JHU/APL as the PEO(TAD) Conceptual Systems Engineer has the general systems engineering responsibilities addressed in 1.3.1.2. The JHU/APL responsibilities for the execution of this plan are as follows:

- Be a member of the Surface Navy TAD Program Management Team;
- Be a member of the System Engineering Team;
- Leads the Step 0 (Operational Needs and Requirements) Work Group;
- Leads the Step 1 (Define the Operational Environment) Engineering Work Group;
- Leads the Step 1 Operational Work Group;
- Leads the Step 2 (Define System Boundaries) Work Group;
- Co-leads the Step 3 (ID System/Subsystem Attributes) Work Group with NSWCDD;
- Co-leads the Step 4 (Establish the Allocated Baseline) Work Group with NSWCDD;
- Leads the development of the Conceptual Performance and Functional Baselines;

- Be responsible for certifying to PEO(TAD) that the Conceptual Performance Baseline is consistent with the operational requirements;
- Be responsible for certifying to PEO(TAD) that the Functional Baseline is consistent with the approved Conceptual Performance Baseline;
- Participates in the reviews by the Flag Steering Committee and ORR, CPBR and TSRR formal reviews.

1.4.2.8 The NSWCDD- Plan Execution Responsibilities

NSWCDD as the PEO(TAD) Systems Development Engineer has the general systems engineering responsibilities addressed in 1.3.1.3. The NSWCDD responsibilities for the execution of this plan are as follows:

- Be a member of the Surface Navy TAD Program Management Team;
- Be a member of the System Engineering Team;
- Co-leads the Step 3 (ID System/Subsystem Attributes) Work Group with JHU/APL;
- Co-leads the Step 4 (Establish the Allocated Baseline) Work Group with JHU/APL;
- Be responsible for the acceptance of the Functional Baseline which includes verification that the Functional Baseline meets the operational requirements and Conceptual Performance Baseline;
- Lead government responsibility for the development of the Surface Navy TAD Allocated Baseline;
- Provides a major supporting role in the execution of the following steps as well as membership in the work groups:
  - Step 0 (Operational Needs and Requirements) Work Group;
  - Step 1 (Define the Operational Environment) Operational Work Group and Engineering Work Group;
  - Step 2 (Define the System Boundaries) Work Group; and
- Participates in the reviews by the Flag Steering Committee and ORR, CPBR and TSRR formal reviews.

1.4.2.9 Step Work Groups

- Step 0 Work Group - A requirements work group of personnel from JHU/APL, NSWCDD and other technical organizations listed in Table 1-1 will be responsible for the collation and reconciliation of the Surface Navy TAD operational requirements and needs. The Requirements Work Group will be the primary forum for reconciliation of the requirements and oversight of the generation of the traceability matrix. The Step 0 Work Group will be led by JHU/APL and supported by NSWCDD.
- Step 1 Work Groups - Two work groups will be established to support different aspects of the operational environment definition. The participants of each work groups are listed in Table 1-1. The work groups have representation from many of the same organizations, but the type of expertise is quite different. Each work group will report to the overall Step Lead, JHU/APL, who will be responsible for coordinating issues and recommendations between work groups and incorporating the recommendations. NSWCDD will support JHU/APL on this effort.

The Operational Work Group will be comprised of warfighters and personnel with experience in fleet operations. The Operational Work Group will provide guidance and review of the operational situations to ensure that they represent how the forces would be deployed and operate.

The Engineering Work Group will be comprised of TAD analysts and design experts. It will provide a preliminary set of threat and environmental characteristics that stress each aspect of the Surface Navy TAD system. The Engineering Work Group also will be responsible for reviewing the documentation of resulting situations to ensure that information required for modeling and evaluation in Steps 3 and 4 is included.

- Step 2 Work Group - To ensure that the functionality of current and future Surface Navy TAD subsystems are captured, representatives from the nomenclatured system technical community will participate in the development of the functional descriptions developed in this step. Series of work groups made up of NSWCDD, JHU/APL, TAD systems engineering personnel, representatives from the nomenclatured systems under consideration, and other personnel listed in Table 1-1 will be utilized to ensure both a consistency of approach and depth and accurate capturing of current and future system functionality and interfaces. The Step 2 Work Group will be led by JHU/APL and supported by NSWCDD.
- Step 3 Work Group - A work group will be formed which will be responsible for the development of the Surface Navy TAD Conceptual Performance Baseline. This work group will identify system attributes, functions and success criteria to be used in the development of the functional, performance and cost requirements for Surface Navy TAD. The work group will be co-led by JHU/APL and NSWCDD and supported by representatives listed in Table 1-1.
- Step 4 Work Group - A work group comprised of personnel from NSWCDD, JHU/APL, PEO(TAD)-SE, effected program managers and systems engineers and other personnel identified in Table 1-1 will be utilized during this step to provide guidance, oversight and detailed planning for the development of the functional and allocated baselines for future Surface Navy TAD. The work group will play a key role in defining the alternatives to be considered and selecting alternatives for detailed analysis and further consideration. The work group will review the final recommended alternative and supporting analyses to ensure all relevant issues have been considered and that it supports the operational, performance and mission success criteria that have been established in earlier steps. The Step 4 Work Group will be co-led by JHU/APL and NSWCDD.

### 1.4.3 Technical Reviews

Figure 1-6 illustrates the PEO(TAD)-SE process with emphasis on the three formal reviews.

- The Operational Requirements Review (ORR) will be held after completion of Steps 0, 1 and 2 to obtain concurrence that the initial requirements, evaluation environment and understanding of the systems involved are adequate to proceed with the identification of the key system attributes and top-level performance requirements in Step 3.
- The Conceptual Performance Baseline Review (CPBR) will be held to present the options, risks and recommendations for the functional and performance requirements for approval prior to Step 4 allocation.
- The TAD System Requirements Review (TSRR) will be held to obtain approval of the recommended Surface Navy TAD baseline and the proposed migration path.

The exit criteria for the reviews will be the approval of the information required at the review and the completion of the step documentation. Additional details on the information presented at each review and the required documentation is provided in the description of each step in Section II and the list of deliverables in Section III. Interim results will be presented to the Flag Steering Committee in several of the steps to obtain general guidance and direction prior to the formal reviews.

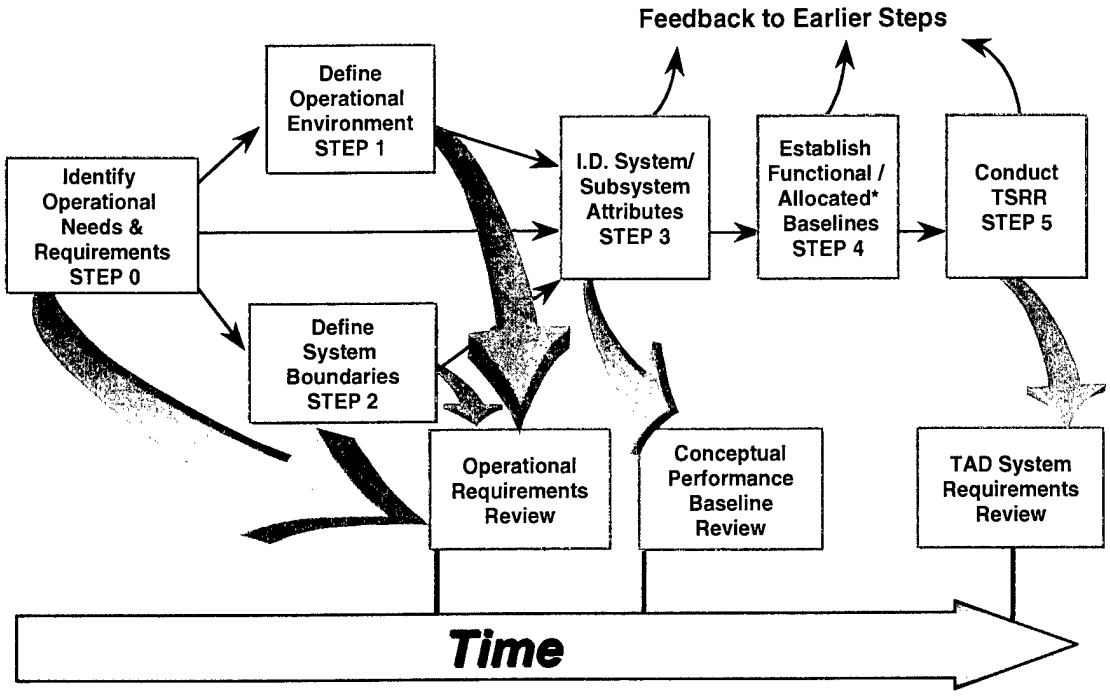



Figure 1-6. Reviews for the System Requirements Engineering Process

### 1.4.4 Internal/External Organizations

A number of Navy and external agencies may have important roles in the TAD program. Surface Navy agencies including SECNAV, CNO, NDC and the systems commands will have significant roles in shaping a Navy-wide approach to theater air defense. Agencies external to the Navy, including JTAMDO, BMDO, DARPA and USMC will have significant roles in shaping a joint warfighting system for theater air defense. The PEO(TAD)-SE organization and system requirements engineering process is expected to establish and maintain appropriate interfaces with each of these agencies. Key agencies and their expected participation in TAD requirements definition and technical review activities are shown in Table 1-1. Industry will be included in Step 4 as part of this process.

### 1.4.5 Customers

Customers are the reason the products of the systems engineering process exist, and as such, are an essential element of those processes. The systems engineers, analysts and technical experts will determine the performance, cost and schedule requirements at the top level. The

primary customers, the end users, require reliable effective solutions to operational problems that are balanced with cost and schedule. The immediate customers, the program managers, continue to refine performance, cost and the schedule constraints throughout the development process in an effort to field successful products to these end users. The end user must understand the capabilities, limitations, design and detailed workings of the systems to be built, since they must eventually use, maintain, and even enhance the delivered system. This plan engages the participation of a number of Navy and external agencies as delineated in Section 1.3.4.

## 1.5 SCHEDULE

After completion of the TSRR, annual updates will be conducted to incorporate lessons learned, evolving new technology and new requirements and to provide training opportunities for systems engineers. Mission and product program SEMPs should then be modified to reflect this annual update.

A summary schedule for executing the Surface Navy TAD system requirements engineering activities is shown in Figure 1-7. Although, Figure 1-2 shows the system engineering process being sequential steps, the first three steps will be executed essentially in parallel. This will enable the interaction and passing of information generated in the various steps. The interaction between the steps is detailed in the step description in Section II and the detailed schedule in Section III. This parallel step execution will reduce the amount of reiteration required and enable the execution of the overall process within two years. In addition to the parallel start of the early steps, the preparations of the modeling and simulation facilities and tools for Steps 3 and 4 will commence at the initiation of the overall plan.

Table 1-1. TAD Key Agency Participation

| ORGANIZATION | REVIEW PARTICIPANTS | | | | | | STEP 0 | STEP 1 | | STEP 2 | STEP 3 | STEP 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FLAG SC | ORR | CPBR | TSRR | SN TAD PROG MGT TEAM | SYS ENG TEAM | WORK GROUP | WORK GROUP ------ ENG | WORK GROUP ------ OPER | WORK GROUP | WORK GROUP | WORK GROUP |
| PEO(TAD) | √* | √ | √ | √ | | | | | | | | |
| PEO(TAD)-SE | √ | √* | √* | √* | √* | √* | | | | | | |
| PEO(TAD) PM SEs | | | | | | √ | | | | | | |
| PEO(TAD)-SE STAFF | | √ | √ | √ | | √ | √ | √ | √ | √ | √ | √ |
| PEO SC | √ | √ | √ | √ | | | | | | | | |
| PEO SC PMs | | √ | √ | √ | √ | | √ | √ | √ | √ | √ | √ |
| PEO SC SEs | | | | | | √ | | | | | | |
| PEO CLA | √ | √ | √ | √ | | | | | | | | |
| NAVSEA 03 (CSSE) | √ | √ | √ | √ | | | √ | √ | √ | √ | √ | √ |
| NAVSEA 05 (CWSE) | √ | √ | √ | √ | | | | | | | | |
| NAVAIR | √ | √ | √ | √ | | | √ | √ | √ | √ | √ | √ |
| CNO N85 | √ | | | | | | | | | | | |
| CNO N88 | √ | | | | | | | | | | | |
| CNO N86 | √ | √ | √ | √ | √ | | √ | | √ | | √ | |
| CNO N6 | √ | √ | √ | √ | | | | | | | | |
| CNO N4 | √ | | | | | | | | | | | |
| BMDO | √ | √ | | √ | √ | | √ | √ | √ | √ | √ | √ |
| SPAWAR | √ | √ | √ | √ | | | √ | √ | √ | √ | √ | √ |
| DASNC4I | √ | | | | | | | | | | | |
| OTHER EFFECTED SYSTEMS PMs/SEs | | √ | √ | √ | √ | √ | √ | √ | | √ | √ | √ |

* Lead

Table 1-1. TAD Key Agency Participation *(Cont'd)*

| ORGANIZATION | REVIEW PARTICIPANTS | | | | | | STEP 0 | STEP 1 | | STEP 2 | STEP 3 | STEP 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FLAG SC | O R R | CPBR | TSRR | SN TAD PROG MGT TEAM | SYS ENG TEAM | WORK GROUP | WORK GROUP ----- ENG | WORK GROUP ----- OPER | WORK GROUP | WORK GROUP | WORK GROUP |
| JTAMDO | √ | √ | | √ | | | √ | | | | | |
| NDC | √ | √ | √ | √ | | | | | √ | | | |
| FLEET CINCS | | √ | √ | √ | | | √ | | √ | | | |
| NSWCDD | | √ | √ | √ | √ | √ | √ | √ | √ | √ | √* | √* |
| NSWC | √ | √ | √ | √ | | | | | | | | |
| NSWCPHD | | | | | | √ | √ | √ | | √ | √ | √ |
| NRaD | | √ | √ | √ | | | √ | √ | | √ | √ | √ |
| NAWC/WPNS CL | | √ | √ | √ | | | √ | √ | | √ | √ | √ |
| OPTEVFOR | | √ | √ | √ | | | √ | √ | | √ | √ | √ |
| USMC | | √ | | | | | | | √ | | | |
| ASN RDA | | √ | | | | | | | | | | |
| JHU/APL | | √ | √ | √ | √ | √ | √* | √* | √* | √* | √* | √* |
| MIT/LL | | | | | | √ | | | | | √ | √ |
| INDUSTRY | | | | | | √ | | | | | | √ |
| INTEL COMMUNITY | | √ | | | | | | √ | | | | |
| OTHER | AS NECESSARY | | | | | | | | | | | |

* Lead

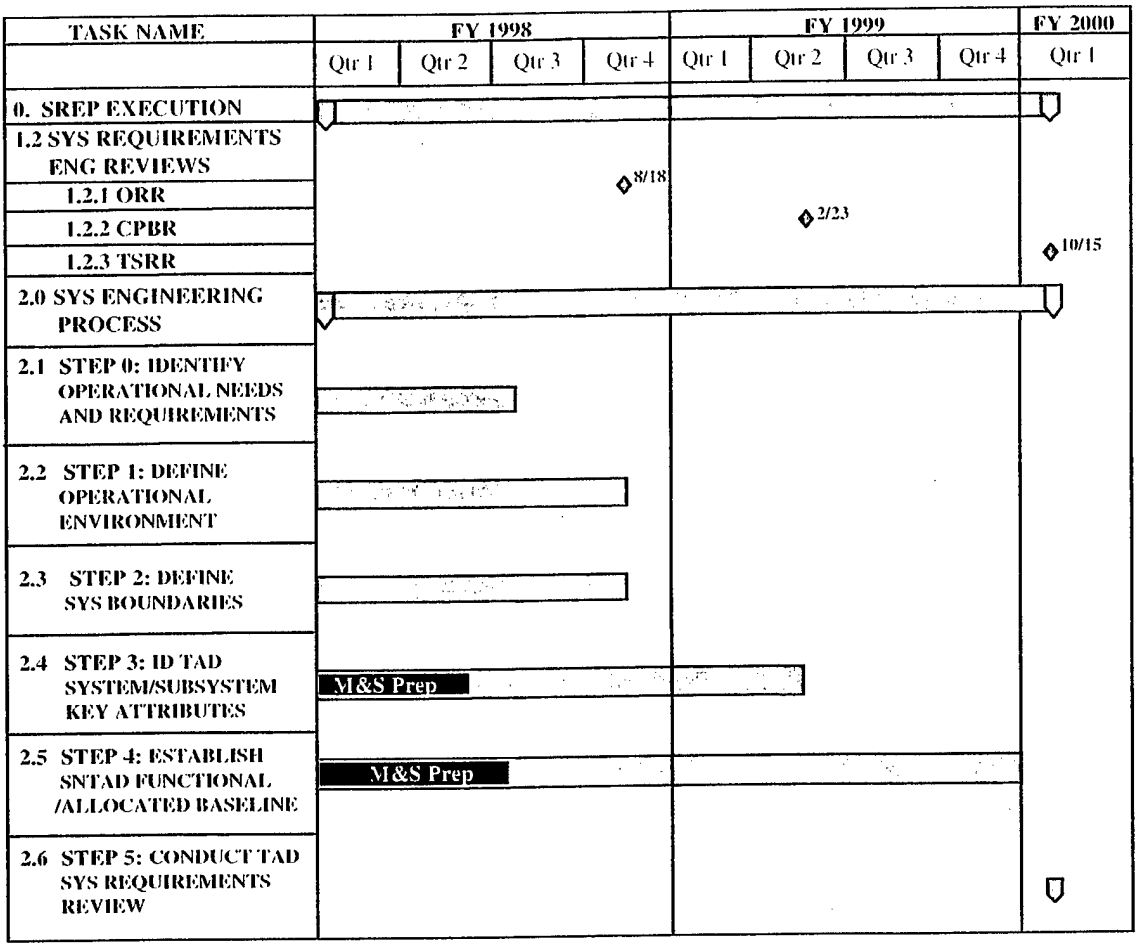



Figure 1-7. System Requirements Engineering Summary Schedule

# SECTION 2

# SYSTEM REQUIREMENTS ENGINEERING PROCESS

This section describes the technical approach and the system requirements engineering process as applied to the Surface Navy TAD system.

## 2.1 INTRODUCTION

As discussed in Section I, TAD system requirements engineering involves a hierarchy of systems. Systems at any one level are embedded in successively higher level systems that address discrete operating tasks, mission areas, and ultimately joint operating forces. Therefore, Surface Navy TAD will be viewed as an integrated system which is comprised of all Surface Navy related Theater Air Defense resources and their interfaces with non-Surface Navy TAD and other Navy assets. This is a "system of systems" made up of various component systems. Similarly, the Surface Navy TAD "system of systems" is a subsystem of the broader Navy TAD, Joint TAD and Theater Air Warfare system of systems. The primary product of this system of systems requirements engineering process is a Surface Navy TAD SRD. The SRDs development will be discussed in the introductory technical approach as well as where appropriate in each of the process steps.

## 2.2 SYSTEM REQUIREMENTS ENGINEERING TECHNICAL APPROACH

The Surface Navy Theater Air Defense system requirements engineering process technical approach is the tailored application of classical systems engineering concepts specifically to meet the needs of the Surface Navy TAD "systems of systems."

The system requirements engineering technical approach described below is founded on lessons learned over the past decades. At the top-level and at every intermediate level, the approach requires the identification of inputs, required outputs, and the processes necessary to produce the outputs. The approach is shown in Figure 2-1.

Inputs: As shown in the adjacent figure, the Surface Navy TAD system requirements engineering approach starts with the identification of inputs. For Surface Navy TAD system requirements engineering, they are:

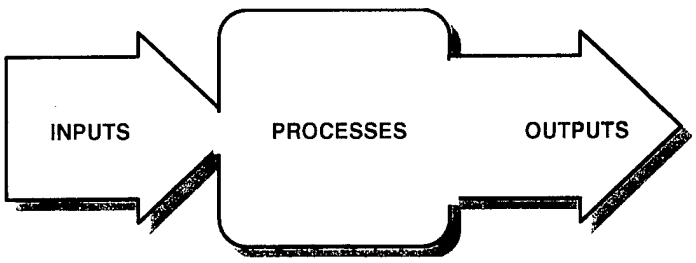



Figure 2-1. PEO(TAD)-SE General Approach

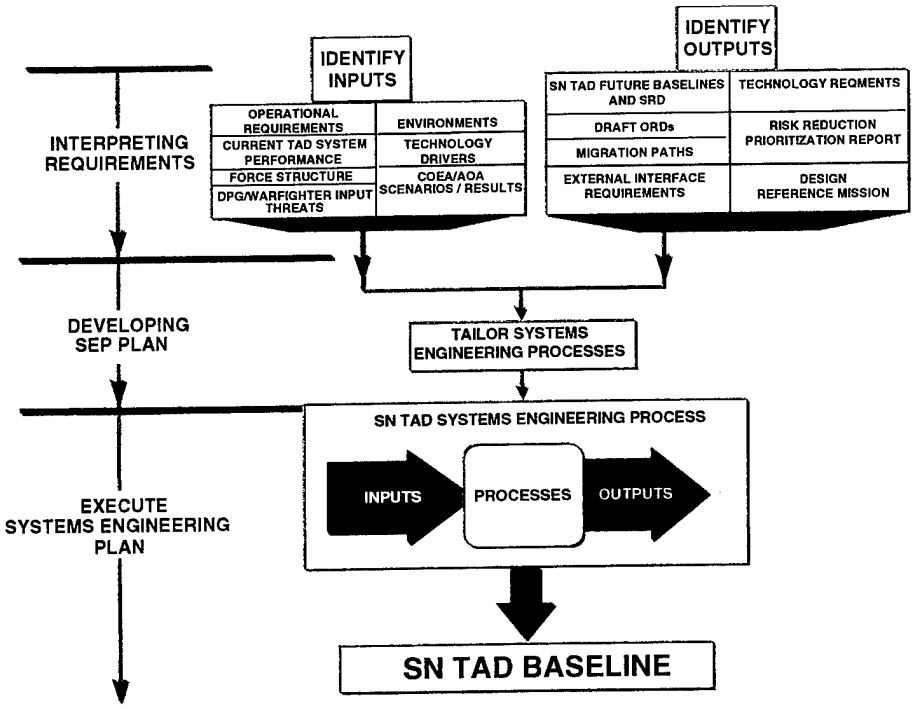
- TAD/FLAG Steering Committee Guidance;
- Current system requirements;
- Mission PM Guidance;
- Current TAD systems and capabilities;
- Projected force structure;
- DPG/Warfighter inputs;
- JTAMDO analysis;
- Current and projected threats;

- Natural and man-made environment (including electromagnetic environmental effects) in which the Surface Navy TAD System must operate;
- Available state-of-the-art technology and technology trends;
  - Results of COEA/AOA scenarios;
  - Results of other TAD studies/analyses; and
  - Analysis tools (e.g. M&S).

Outputs: Outputs are the next actions identified. The outputs are defined early, as they determine the required inputs and dictate processes. For engineering an integrated combat system of systems such as Surface Navy TAD, the outputs consist of:

- The Surface Navy TAD future baseline requirements which will comprise the System Requirements Document;
- Draft ORDs;
- Migration paths to achieve the Surface Navy TAD baseline;
- Interface requirements recommendations for non-Surface Navy TAD Systems contributing to the Surface Navy TAD mission;
- Technology development requirements;
- Risk Reduction Prioritization Report; and
- Design Reference Mission.

The final element is defining the processes required to take the input and perform the actions which are required to deliver the desired output. PEO(TAD)-SE has developed a common system requirements engineering process which is described in Section 2.2. Each of the system requirements engineering steps must remain under continuous scrutiny for iterative improvement as this plan is executed. PEO(TAD)-SE's system requirements engineering technical approach for Surface Navy TAD is shown in Figure 2-2.




2-2. Surface Navy TAD System Requirements Engineering Technical Approach

### 2.2.1 System Requirements Engineering Process Tool Selection

To facilitate the large amount of information that needs to be collected and analyzed, a systems engineering tool or set of tools will be selected. These tools are computer programs and databases designed to support and track data collected and developed during the system requirements engineering process. This system engineering tool does not include performance and cost modeling and simulation. See Sections 2.1.2 and 2.6.3. It will be a goal to select a tool that will be compatible with lower level TAD systems development tools. The systems engineering tools must provide the following capabilities:

- Traceability of top down requirements and functions;
- Extraction of requirements and descriptions from existing documentation;
- Building of functional and physical hierarchical models and provide mapping between the models;
- Modeling of control features as well as data flow;
- Analysis of interfaces; and
- Generation of reports which are compatible with standard word processing and graphics tools.

Candidate systems engineering tools are:

| Tool | Company |
|---|---|
| RDD-100 | Ascent Logic Corp. |
| ProductTrack | Cimflex Tecknowledge Corp. |
| Vital Link | Compliance Automation, Inc. |
| RTM | Marconi Systems Tech. |
| Cradle SEE | Mesa Systems Guild, Inc. |
| SpecWriter | PRC Inc. |
| SLATE | TD Technologies |
| Require | Unisys Corp. |
| CORE | Vitech Corp. |
| DOORS | Quality Systems Software (QSS) Corp. |
| CASETS | Boeing |

### 2.2.2 Modeling and Simulation Tool Selection

To assess system performance, it is necessary to use modeling and simulation tools. Several different types of models (in particular cost and performance models) may be needed to address the entire system. Critical functions and attributes will need to be analyzed to identify the most cost effective and highest performance system. Section 2.6.3 addresses the modeling strategy needed to select the proper modeling and simulation tools.

### 2.2.3 Communications

The use of templates for select elements of the system requirements engineering process can greatly aid the systems engineer to ensure commonality of process and resulting products. The template, as well as guidelines for its use, will be maintained in an electronic program library. To this end, TAD will use the following documentation template for the communication of system requirements engineering results:

- Systems Engineering Memorandum (SEM). The SEM will be the prevalent template used across the program. All documentation associated with technical baseline development, modification including cost and schedule, trade studies, risk assessments or verification will be attached or documented in the SEM.

- Additional templates may be used if warranted as the system requirements engineering process is executed.

### 2.2.4 Documentation of Results

Documentation management, process documentation and configuration control are important activities in traditional systems engineering and are ever more crucial in IPPD implementation. The concurrency of efforts, the numerous tradeoffs being conducted and successive prototypes under investigation make the documentation process an integral part of IPPD implementation. The primary product of the system requirements engineering effort described in this plan is the SRD. The process for the SRD's development is illustrated in Figure 1-3. The details on other documents and configuration management baselines are addressed in each step of the system requirements engineering process.

### 2.2.5 The Surface Navy TAD System Requirements Engineering Processes

The Surface Navy TAD system requirements engineering process to be used is a six step common process culminating in the identification of the Surface Navy TAD future baseline requirements (System Requirements Document), interface requirements recommendations for non-Surface Navy TAD systems contributing to the Surface Navy TAD mission, definition of migration paths, identification of technology development requirements, and production of analysis reports on which the Navy's senior leadership can concur and support POM planning.

PEO(TAD)-SE has developed a common system requirements engineering process. This process is initiated by the capture of the mission requirements which has been included as Step 0 in this plan. Each step has been summarily decomposed into its respective sub-processes and is described in Sections 2.3 through 2.8 of this plan. Decomposition of each step follows the model described previously in that inputs, processes and outputs are identified for each step. At the top-level as well as at each sub level (step) the processes need to be flexible, responsive, and designed with control points to measure effectiveness.

The six system requirements engineering steps followed by this document are:

- Step 0: Identify operational needs and requirements;
- Step 1: Define the operational environment in which Surface Navy TAD will perform;
- Step 2: Define the system's boundaries;
- Step 3: Identify TAD system/subsystem key attributes;
- Step 4: Establish the Surface Navy TAD Functional/Allocated Baselines;* and
- Step 5: Conduct a TAD System Requirements Review (TSRR).

As shown in Figure 2-3, the system requirements engineering process is not a single pass action. Each step can identify new items required from previous steps, creating feedback through an interactive looping action.

* The Allocated Baseline is in the form of an SRD which the respective Program Offices will use to develop their combat system products.

### 2.2.6 Surface Navy TAD SRD Development Overview

A primary product of the Surface Navy TAD system of systems requirements engineering process is an SRD. The SRD will address multiple requirements levels from the operational requirements at the warfighter mission level, the PEO(TAD) mission programs, and finally to the product programs. This process is illustrated in Figure 2-4, which shows the development of each section of the SRD at each step in the process as well as the formal reviews. While Figure 2-4 shows the SRD generically, the SRD will be developed to conform to the SRD format being developed by PEO(TAD)-SE.

## 2.3 STEP 0 – IDENTIFY OPERATIONAL NEEDS AND REQUIREMENTS

The purpose of this step in the system requirements engineering process is to collate and reconcile the operational requirements and needs for the existing systems that are considered within the scope of the Surface Navy TAD system. Since many of the operational requirements are not clearly defined for the Surface Navy TAD "system of systems" it is important to have an understanding of the legacy requirements.

Figure 2-5 illustrates the process for collecting and tracking the known TAD mission area requirements from the Joint mission and threat to the nomenclatured system requirements and organizing them into a coherent hierarchical structure. It also illustrates that after initial identification, the requirements are continually being modified via feedback as the other system requirements engineering steps are performed.

Step 0 is intended to help answer the following fundamental questions to set the stage for the subsequent steps:

- What are the existing operational requirements, both Navy and Joint?
- What are the relationships of these requirements?
- What existing "subsystem" requirements overlap or conflict and what top-level system requirements are missing?
- What are reasonable resolutions to the deficiencies in operational requirements? and
- What are the affordability constraints that will bound the Surface Navy TAD "system" solution?

Figure 2-6 diagrams the process that will be used to answer the previous questions.

### 2.3.1 Step 0 Inputs

- Flag Steering Committee Guidance - General guidance will be provided by the PEO(TAD) led Flag Steering Committee.
- Existing and Projected Requirements - The primary input to Step 0 is the existing and projected operational requirements and needs for the systems that fall within the Surface Navy TAD "system of systems". Current Surface Navy TAD systems are listed in Table 2-1 of Section 2.5.2.

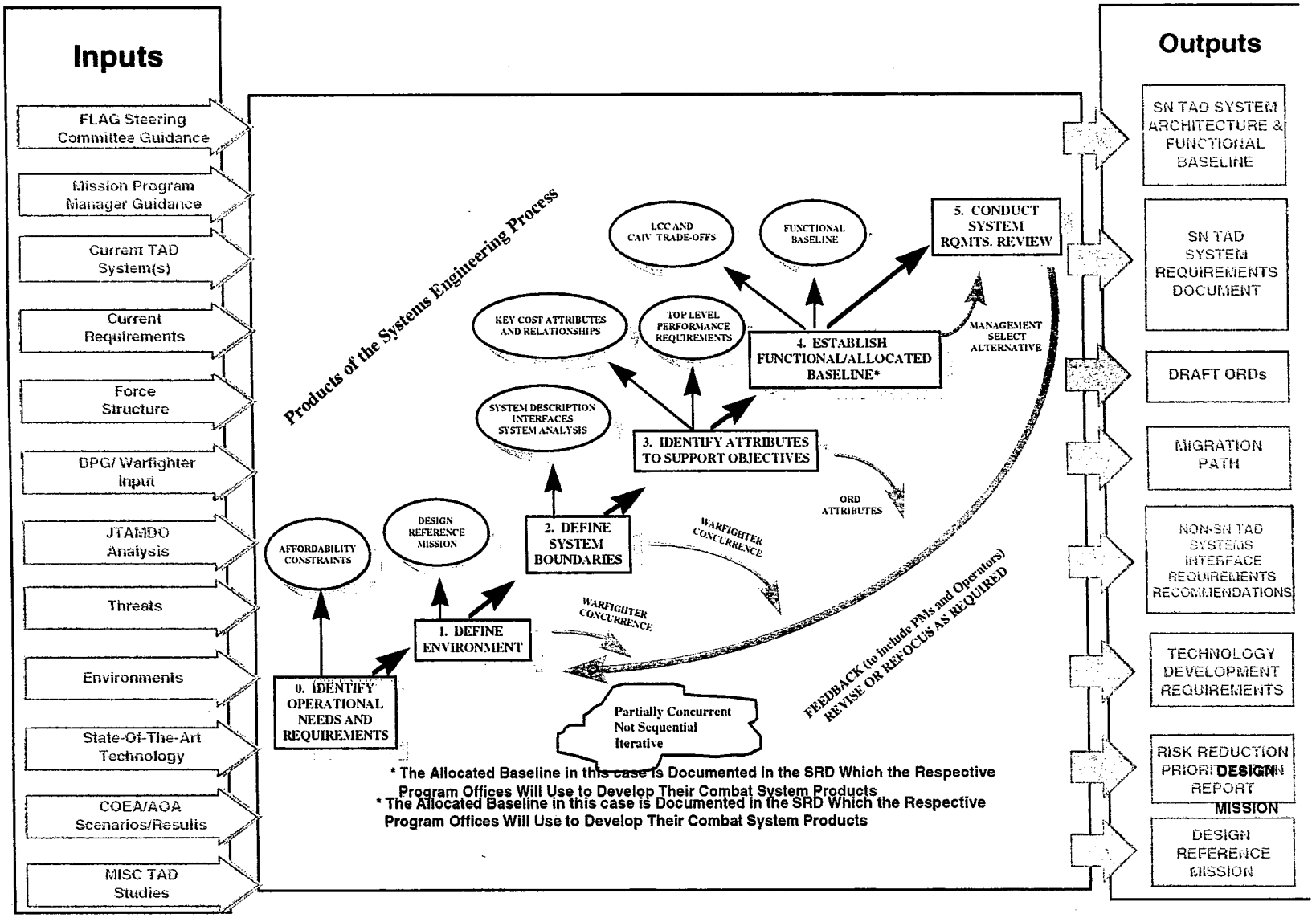



Figure 2-3. Surface Navy TAD System of Systems Requirements Engineering Process

| SRD | SN TAD SYSTEM ENGINEERING PROCESS | | | | | |
|---|---|---|---|---|---|---|
| | Step 0 | Step 1 | Step 2 | Step 3 | Step 4 | Step 5 |
| Scope of the System | | | Initial Draft | | Final | SRD Approval |
| Threats/Environment | Initial Draft | Prelim. | | | Final | |
| Operational Requirements | Initial Draft | | | Prelim. | Final | |
| SN TAD Functional Requirements | | | Initial Draft | Prelim. | Final | |
| SN TAD Technical Performance/MOEs | | | | Prelim. | Final | |
| SN TAD Interface Requirements | | | Initial Draft | | Final | |
| SN TAD Verification Requirements | | | | Prelim. | Final | |
| Allocated Functional/Performance | | | | | Final | |
| Interface Requirements | | | | | Final | |
| Allocated Verification Requirements | | | | | Final | |
| Reviews | | ORR | | CPBR | TSRR | |

Figure 2-4. Development of the Surface Navy TAD SRD

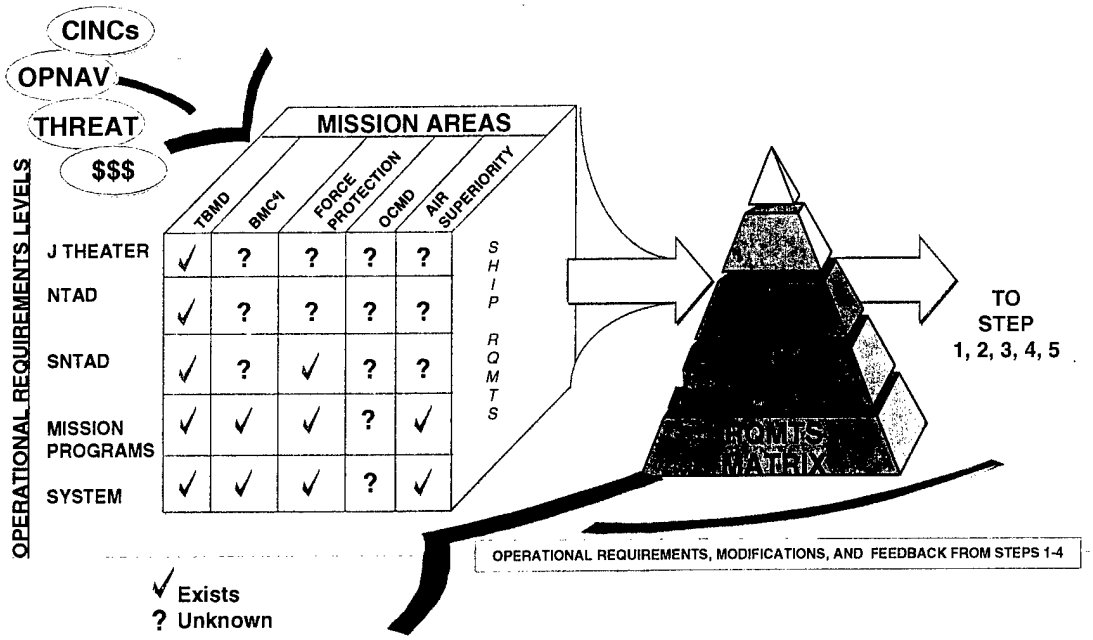



Figure 2-5. Identify Operational Needs and Requirements

- Threats - Threat information will be collected from multiple sources. The individual system operational requirements documents and System Threat Assessment Reports (STARs) will contain threat information against which each system was designed. More detailed threat information will be obtained and coordinated with the recently formed PEO(TAD) and PEO SC threat cells and with the Joint Guidance and Policy Paper (JG&PP) #97-01.
- Feedback - Step 0 documents an initial set of operational requirements and establishes traceability. These requirements will be modified and further defined by Step 2 as the "system of system" boundaries are better defined, by Step 3 as the key requirements are determined and by Step 4 as the requirements are allocated within the limits of the legacy systems and state-of-the-art technology.

### 2.3.2 The Scope of the "System"

The scope of the system has been defined as the Surface Navy TAD in context of Joint Theater Air Warfare (TAW) including interfaces to other Navy and Joint assets. Functionally Surface Navy TAD includes missions that either traditionally have been considered as relatively independent or are new to the Navy. These include Theater Ballistic Missile Defense (TBMD), Air Superiority, Force Protection, Overland Cruise Missile Defense (OCMD), and BMC$^4$ I. The details of what nomenclatured systems will be considered will be worked in conjunction with Step 2 which defines the boundaries and functionalities of the Surface Navy TAD "system of systems".

### 2.3.3 Gather the Known Requirements

Many of the theater, system and subsystem operational requirements and needs have been developed under the guidance of Capstone Requirements, individual Mission Needs Statement (MNS), Operational Requirements Documents (ORD) or equivalent documents for legacy systems. Each of these documents along with any future system or Mission Capstone Requirements will be collected. If these documents do not exist for some of the legacy systems the top-level requirements will be obtained from their respective requirements specifications.

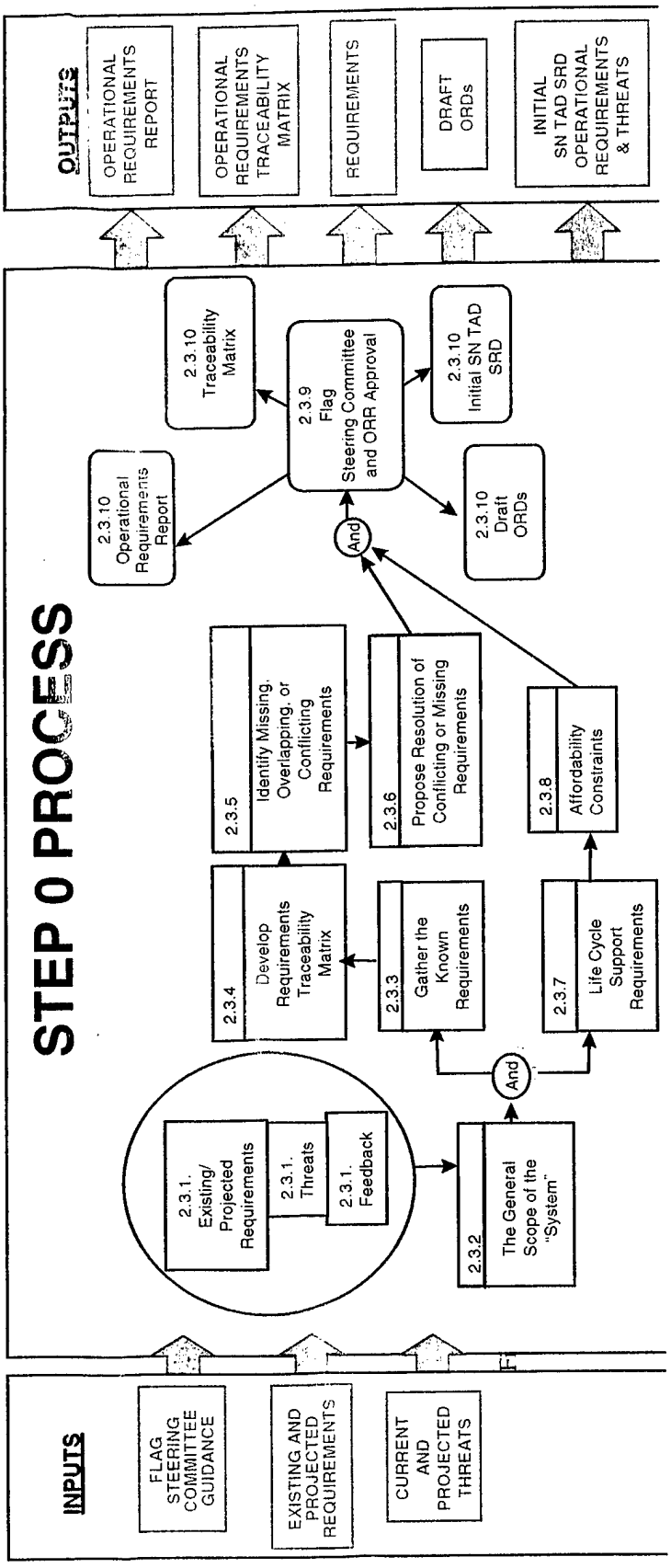



**Figure 2-6. Identify Operational Needs and Requirements Process**

Table 2-1. Shipboard Systems

| SYSTEM | Subsystem of What Higher Level System | Subsystem Of Surface Navy TAD |
|---|---|---|
| **SENSOR SYSTEMS:** | | |
| SPY-1 | | √ |
| SPY-1 TBMD Variants | AEGIS WS | √ |
| SPS-49 | | √ |
| MK 23 Target Acquisition System (TAS) | | √ |
| SPS-48 | | √ |
| Phalanx Radar * | MK15 CIWS | √ |
| SPQ-9B | MK 86 GFCS | √ |
| Advanced Integrated Electronic Warfare System (AIEWS) ESM* | AIEWS | √ |
| SLQ-32 ESM* | SLQ-32 | √ |
| Thermal Imaging Sensor System (TISS) | | √ |
| Infrared Search and Track (IRST) | | √ |
| Volume Search Radar (VSR)*** | | √ |
| X BAND Multifunction Radar (MFR)*** | | √ |
| **IFF SYSTEMS:** | | |
| Central Identification Friend or Foe (CIFF) UPX-36 | | √ |
| UPX-29 Interrogator System | | √ |
| Shipboard Active Radar Track Identification System (SARTIS) | | √ |
| MK XII IFF Interrogator (UPX-24 & 27) | | √ |
| **DATA LINKS AND COMMUNICATIONS SYSTEMS:** | | |
| Cooperative Engagement Capability (CEC) | | √ |
| Link 11- Tactical Digital Information Link A (TADIL A) | | |
| Link 16 - Joint Tactical Information Distribution System (JTIDS) (i.e. TADIL J) | | |
| OTCIXS | | |
| Tactical Information Broadcast System (TIBS) | | |
| TRAP TRE / TDDS | | |
| TADIX A | | |
| TACINTL | | |
| Joint Maritime Communications (JMCOMS, including secure voice) | | |
| **BATTLE MANAGEMENT AND $C^3I$ SYSTEMS:** | | |
| Global Command and Control System (GCCS-M) Shipboard connectivity via JMCIS | | |
| Global Broadcast System (GBS) | | |
| AADC – Area Air Defense Commander*** | | √ |
| AEGIS Display System (ADS) | AEGIS WS | √ |
| TIMS – TFCC (Tactical Flag Command Center) Information Management System | | |

Table 2-1. ShipBoard Systems (Continued)

| | | |
|---|---|---|
| **COMBAT DIRECTION SYSTEMS:** | | |
| AEGIS Command & Decision (C&D) | AEGIS WS | √ |
| Ship Self Defense System (SSDS ) MK 0 | | √ |
| SSDS MK 1 | | √ |
| Advanced Combat Direction System (ACDS) BLOCK 0 | | √ |
| ACDS BLOCK 1 | | √ |
| Integrated Combat Direction System (ICDS) | | √ |
| AKCITA*** | | √ |
| SEA ATHENA*** | | √ |
| **WEAPON CONTROL SYSTEMS:** | | |
| AEGIS Weapon Control System (WCS) | AEGIS WS | √ |
| **MISSILE FIRE CONTROL SYSTEMS:** | | |
| AEGIS FCS | AEGIS WS | √ |
| RAM FCS | | √ |
| NATO SEASPARROW FCS | | √ |
| **MISSILES:** | | |
| SM-3 (Navy Theater Wide TBMD) | | √ |
| SM-2 Block III, IIIA, IV, IVA | | √ |
| MK 31 Rolling Airframe Missile (RAM) | | √ |
| MK 57 NATO Sea Sparrow | | √ |
| Evolved SEA SPARROW Missile (ESSM) | | √ |
| **LAUNCHING SYSTEMS:** | | |
| MK 13 GMLS | | |
| MK 26 GMLS | | |
| Self Defense Launcher System (SDLS) | | |
| MK 41 Vertical Launching System (VLS) | | √ |
| MK 29 GMLS | | √ |
| **MEDIUM CALIBER GUN SYSTEMS:** | | |
| MK 86 GFCS with MK 45 Gun | | √ |
| MK 34 GWS (i.e. DDG51 GWS) | | √ |
| **SHORT RANGE GUN SYSTEMS:** | | |
| MK 15 Phalanx CIWS* | CIWS | √ |
| **ELECTRONIC ATTACK SYSTEMS:** | | |
| SLQ-32 ECM* | SLQ-32 | √ |
| AIEWS EA* | AIEWS | √ |
| MK 216 Sea Gnat Distraction Chaff | ** | √ |
| MK 214 Sea Gnat Seduction Chaff | ** | √ |
| MK 182 Super Rapid Blooming Offboard Chaff (SRBOC) | ** | √ |
| MK 186 Giant IR Decoy | ** | √ |
| NULKA Decoy | ** | √ |
| MK 36 Decoy Launcher | ** | √ |
| MK 53 Decoy Launching System | ** | √ |
| SLQ-49 Inflatable Radar Decoy | ** | √ |

Table 2-1. ShipBoard Systems (Continued)

| SUPPORT SYSTEMS: | ** | |
|---|---|---|
| BFTT | | |
| Navigation Sensor System Interface (NAVSSI) | | |
| AEGIS Combat Training System (ACTS) | AEGIS WS | √ |
| AEGIS Operational and Readiness Test System (ORTS) | AEGIS WS | √ |
| WSN-5 | | |
| WSN-7 | | |
| Global Positioning System (GPS) | | |
| TACAN - Tactical Air Navigation | | |
| Shipboard WAN | | |

* Functional Partition of a Higher Level Nomenclatured System.

** For purposes of this effort the noted EA elements will be treated as part of either the SLQ-32 EA Subsystem or the AIEWS EA Subsystem.

*** New initiative.

The gathering of requirements has been artificially divided into two pats. Section 2.3.3 through 2.3.6 will focus on the technical requirements that predominantly affect the system functionality; such as performance, data interfaces, electromagnetic compatibility and human machine interfaces. Sections 2.3.7 and 2.3.8 will focus on the support requirements and life cycle cost. This split was done to emphasize that the balance between performance and cost that is being evaluated is concerned with the full life cycle cost not just the initial system procurement. There will be many requirements identified during this step that relate both paths (e.g., reliability, training) that will be coordinated during the execution of the substeps.

2.3.3.1 Existing System Requirements

The AAW and TBMD Capstone Requirements are a primary source of top-level operational requirements and needs. Copies will be obtained of the system requirements documents for the relevant Navy and Joint programs. In addition to the system level requirements, the TAD requirements for ship classes will be considered (e.g., LPD-17, DD-21, and CV(X)). The systems can be divided into two major varieties: those that fall within the Surface Navy TAD system and those that are external to Surface Navy TAD but directly interface or support the Surface Navy TAD mission. Preliminary lists of the shipboard and non-shipboard systems that are considered part of Surface Navy TAD or relate to Surface Navy TAD are given in Tables 2-1 and 2-2 located in Step 2, Section 2.5.2. The final set of systems for which requirement documentation will be collected and analyzed will be coordinated with Step 2 which defines the boundaries and associated systems.

Table 2-2. Non-Shipboard Systems

| NON-SHIPBOARD SYSTEMS |
|---|
| TPS - 75 |
| TPS - 59 |
| THAAD/GBR |
| TACDAR |
| SENIOR SCOUT |
| S-3B |
| RIVET JOINT |
| Patriot |
| LAMPS ESM SYSTEM |
| LAMPS |
| JTAGS |
| Joint Strike Fighter |
| HAWK |
| GUARDRAIL |
| Global Command and Control System (GCCS) |
| F-22 |
| F-15 |
| F-14 |
| F/A-18 E/F |
| ES-3A |
| EA-6B |
| E-2C |
| Defense Support Program (DSP) |
| DARK STAR |
| AWACS |
| AV-8B |
| APS - 145 (E-2C Radar) |
| ALERT |
| Airborne IRST Ladar Systems |
| AEROSTAT |
| ABL (Airborne Laser) |
| AABCC |
| Space Based Infrared System (SBIRS) |
| APY-1/2 (AWACS Radar) |

2.3.3.2 Projected Requirements

In addition to gathering the current systems' requirements documents, other organizations will be contacted to identify preliminary requirements being considered for future systems which may impact the Surface Navy TAD overall requirements. The focus will be on the requirements for new systems and modifications to existing systems being included in POM 00. Additional sources of evolving requirements include, but are not limited to:

- BMDO
- NAVSEA
- PEO CLA
- NDC
- CNO N86
- PEO(TAD)
- ONR
- SPAWAR
- PEO SC
- CNO N6
- CNO N85
- FLEET CINCs

- CNO N88
- USMC
- PEO SCS
- NAVAIR

The candidate systems and requirements will be presented to the Flag Steering Committee for review and approval.

2.3.4 Develop Operational Requirements Traceability Matrix

Once the requirements for the various systems involved are collected they will be organized into an Operational Requirements Traceability Matrix that shows the decomposition, relationship and allocation from the top-level requirements. Requirements will fall into three basic categories: quantifiable performance, functionality and interoperability/compatibility constraints. During this process the level of detail addressed will be limited in order to keep the number of requirements being tracked to a manageable level.

A Requirements Work Group of TAD experts will be used to generate and manage the operational requirements as well as resolving conflicts and identifying missing requirements. The Requirements Work Group will be led by JHU/APL. See Table 1-1 for Work Group participants.

To facilitate the development of the Operational Requirements Traceability Matrix an automated requirements tracking tool will be used. The requirements from each of the documents collected in Section 2.3.3 will be entered into a database to show the relationship between elements and higher level systems. Each requirement will be reviewed to determine the documented allocation and relationship to both upper and lower level systems. For many of the nomenclatured systems that are subsystems of Surface Navy TAD there will be no documented link to higher level system requirements since many of these elements were developed essentially as stand alone systems. When collecting and organizing the requirements it must be recognized that many of the Surface Navy TAD individual systems have performance and functionality that support other mission areas outside the scope of Surface Navy TAD. These requirements will not be analyzed but must be noted for consideration in later steps when determining the migration path.

2.3.5 Identify Missing, Overlapping or Conflicting Requirements

After the explicit allocations and relationships are identified from the formal documentation, the entire Operational Requirements Traceability Matrix will be reviewed to identify and highlight problems and weaknesses which will be addressed in later steps of the system requirements engineering process. For example, the requirements stated at the theater and system level may not have been allocated or decomposed to element level requirements. The more likely situation is that the element level operational requirements will have numerous details that are not directly upwardly traceable. These additional requirements will be evaluated not to determine if the quantified numbers are supportable but to determine if they are indirectly decomposed from a higher operational requirement.

As the requirements for all of the elements are reviewed there will be requirements that appear more than once. These situations may indicate areas for potential cost savings by eliminating redundancy or defining clear delegation of responsibility. Also these situations may highlight areas for common application of technology such as signal processing or display software. Each case will be evaluated to determine if the redundancy is intentional for robustness, cost of updating legacy designs, system integration simplification or some other valid reason.

One of the most serious situations that will be identified is conflicting requirements. This could occur as a result of uncoordinated development or the fact that requirements have been misinterpreted or changed.

Since many of the elements included within the Surface Navy TAD "system of systems" were developed many years ago, the requirements will be evaluated to determine if they are obsolete or when they will be. Two examples of obsolete requirements are references to outdated threats and interfaces to systems that no longer exist. The identified obsolescence will be highlighted for more detailed evaluation in Steps 2, 3 and 4.

2.3.6 Propose Resolution of Conflicting and Missing Requirements

To finish the development of the Operational Requirements Traceability Matrix recommendations will be made to resolve the issues raised in Section 2.3.5. It is not the intent of Step 0 to perform detailed analyses and determine the final solution but rather to provide a reasonable starting point and document the assumptions that lead to the recommendations. As part of that documentation a list will be developed of the element interfaces, functionality and performance that need further definition and analysis. This list will be incorporated in the Step 2, 3 and 4 studies and analyses as appropriate to verify and refine the proposed requirements.

The Requirements Work Group will utilize a structured top-down process to review and assess the operational requirements and top-level functions of a Surface Navy TAD system. The Requirements Work Group will start with the Surface Navy TAD mission and identify the tasks involved then develop a set of operational requirements to perform the tasks. The results of the structured requirements review process will provide insight into the missing requirements traceability and provide recommendations for additional operational requirements that will be used until the detailed analysis is performed in Steps 3 and 4.

A major product of this task will be a set of draft ORDs and upper level documentation of the various mission area requirements in the context of the Navy wide TAD and full Joint TAD.

2.3.7 Life Cycle Support Requirements

One of the objectives of this overall system requirements engineering task is to identify Life Cycle Cost savings which can be used to fund the recommended changes. As part of the effort to bound the scope of the analysis it is important to identify the support requirements. Without some reasonable understanding of these constraints considerable effort could be expended examining potential solutions that would ultimately be unsupportable.

Since system support is a key factor in total system Life Cycle Cost, the Surface Navy TAD System Life Mission Support assumptions will be identified. It may be very difficult to identify a single philosophy since virtually the entire current system is fielded with a support structure already in place. At a minimum, the following elements of supportability shall be analyzed:

- Maintenance Planning
- Facilities
- Supply Support
- Support Equipment
- Packaging, Handling, Storage & Transportation (PHS&T)
- Training and Training Support
- Computer Resources Support
- Manpower and Personnel
- Design Interface
- Technical Data

2.3.8 Affordability Constraints

To bound the study options that need to be considered, affordability constraints will be developed. The affordability of the Surface Navy TAD must be considered for a defined system life for all legacy systems and new or changed systems that result from the integration into a coherent Surface Navy TAD System. The primary sources of affordability information are the POM budget, the Program Managers, and the Surface Navy TAD Flag Steering Committee. The budgetary estimates will include not only RDT&E and SCN costs but an estimate of the operational and support costs once the system is developed.

Once the cost of the legacy systems is determined, an estimate of the Surface Navy TAD budget and how the total budget trend is anticipated to extend until 2015 will be developed.

2.3.9 Flag Steering Committee and Operational Requirements Review

At the end of the previous tasks the result will be a completed Operational Requirements Traceability Matrix that defines the operational requirements. Some entries will be fully documented and others will simply be recommendation with loose rationale. The Traceability Matrix will be reviewed with the TAD Flag Steering Committee to receive general guidance and agreement that the operational requirements and needs have been correctly captured and interpreted. It will be made very clear that these are not intended to be the final Surface Navy TAD requirements but merely representative and complete enough to begin the more rigorous system requirements engineering analysis.

At the completion of Steps 0, 1 and 2, an Operational Requirements Review (ORR) will be held. The Operational Requirements Traceability Matrix is the primary output of Step 0 that will be presented at the ORR. The details of the entire Traceability Matrix can not be reviewed at the ORR. The ORR will focus primarily on the requirements issues, proposed resolutions with supporting rationale and a discussion of the additional analysis required. The ORR will be chaired by PEO(TAD)-SE and jointly hosted by JHU/APL and NSWCDD. The participants in the ORR are listed in Table 1-1.

2.3.10 Step 0 Products

- Requirements Library - This library will not actually be a delivered product but rather a single source for all of the related requirements documents including the requirements database. The library will need to be maintained and updated throughout the remaining steps.
- Operational Requirements Traceability Matrix - The Operational Requirements Traceability Matrix will show the decompositions from Joint TAD Mission needs to element operational requirements.
- Operational Requirements Report - The Requirements Report will document the requirement issues that were discovered in Section 2.3.5 along with the rationale and proposed resolution of the issues developed in Section 2.3.6. The report also will include the supportability assumptions and affordability constraints developed in Sections 2.3.7 and 2.3.8.
- Draft ORDs - A set of draft ORDs, modifications to existing ORDs and top-level documentation will be developed to reflect the recommended Operational Requirements that result from the development of the Surface Navy TAD Operational Requirements Traceability Matrix. These documents will only be drafts with suggested requirements and placeholders for the quantitative parameters. These documents will be updated at the completion of Step 3 and again after Step 4.

- Initial Surface Navy TAD SRD Operational Requirements and Threats - The Mission Area Operational Requirements captured in this step will be documented in a draft of the SRD. The threats and operational environment will also be drafted for inclusion in the SRD.

## 2.4 STEP 1 - DEFINE THE OPERATIONAL ENVIRONMENT

The purpose of this step is to define the Surface Navy TAD 2015 Design Reference Mission which details the operational environment within which the system attributes and requirement allocations are evaluated. Accurate and complete specification of the DRM is required to support the evaluation of allocation alternatives and to communicate to the Surface Navy TAD design team the relative importance of design characteristics. The DRM will be the baseline used to evaluate the relative merit of proposed system concepts and upgrades for the TAD mission area.

The DRM will define the campaign at several levels as illustrated in Figure 2-7. The individual engagements will be defined in detail to enable evaluation of individual system performance. Multiple engagements will be combined into Operational Situations (OPSITs) which will be used to evaluate Surface Navy TAD in the broader context of a joint task force. The OPSITs will then be combined into a full joint force theater wide campaign. The DRM is an engineering tool that will be used in the evaluation of the Surface Navy TAD "system of systems" to stress all aspects of the system from performance and functionality to interoperability and supportability.

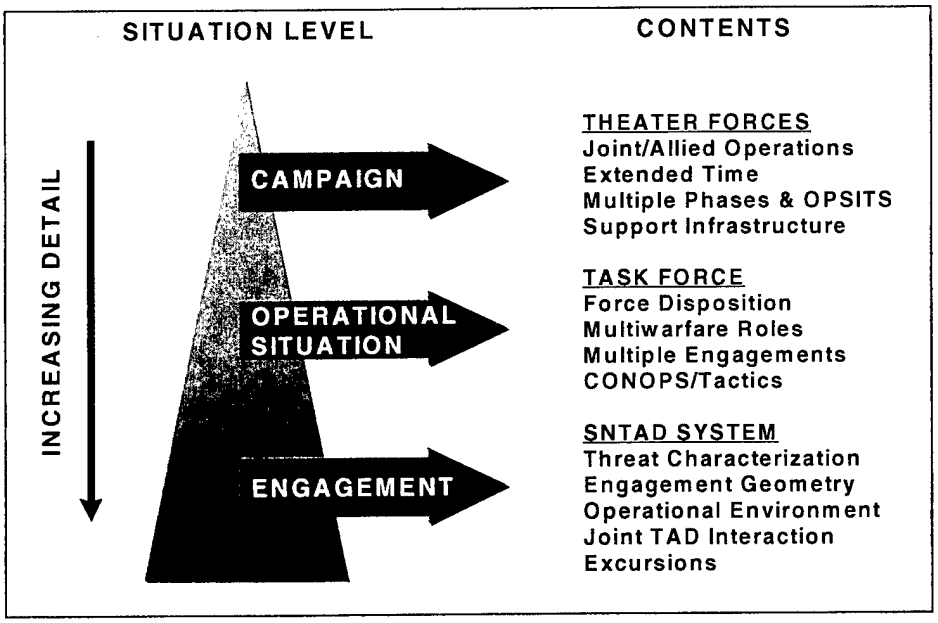



Figure 2-7. DRM Domain

Figure 2-8 shows the DRM will be more than a single event with specific threats. The DRM will define the total envelope of the operational environments in which the Surface Navy TAD System must perform from the early stages of initial presence to the end of hostilities. The DRM will be time sequenced to represent the spectrum of the Joint Theater Air Defense

Mission. Figure 2-9 represents two potential operational environments in the time sequenced DRM.

The DRM will consist of politically and geographically generic OPSITs with specific representative threats. The DRM will specify the entire operational environment not just the threats, raid sizes and timing. This will included the physical phenomena such as clutter and propagation effects as well as EW and system availability. The DRM will contain the necessary features and details to evaluate each of the requirements from the Operational Requirements Traceability Matrix.

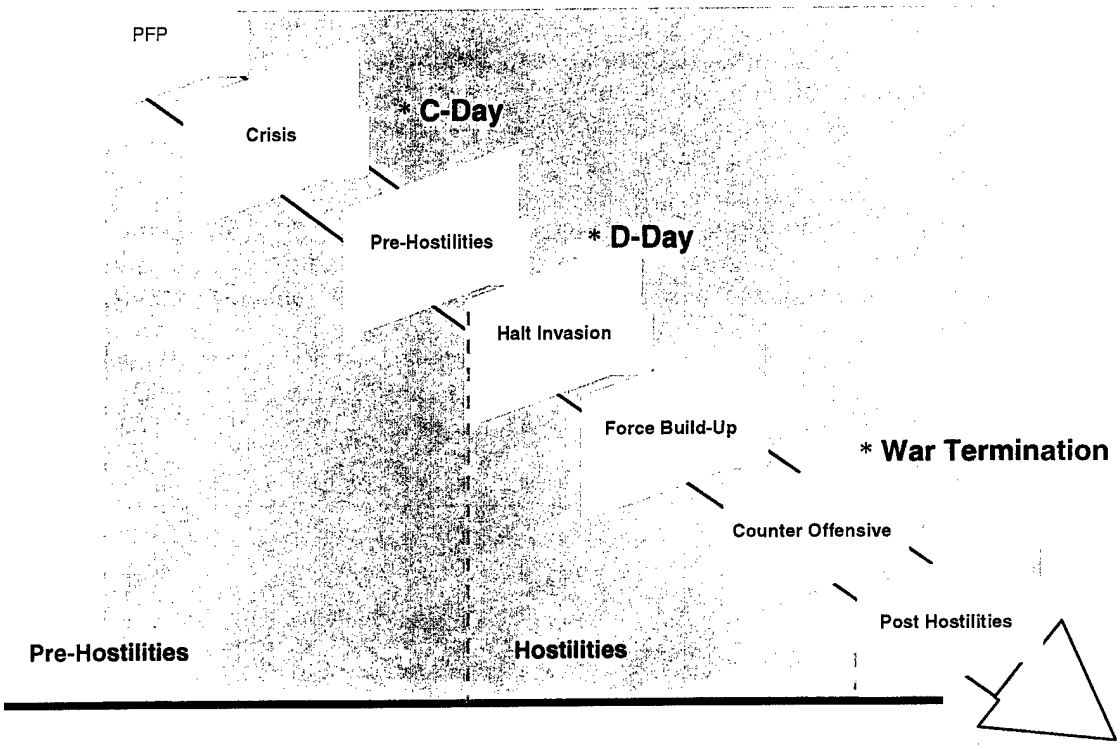



Figure 2-8. DRM Total Envelope

In addition to the development of the DRM, Step 1 will answer the following fundamental questions to focus the subsequent steps and establish a clearer understanding of the features that need to be modeled:

- What specific OPSITs will be evaluated?
- For what combination of OPSITs will the Surface Navy TAD design be optimized?
- What Concept of Operations (CONOPs) and Rules of Engagement (ROEs) will be assumed for each OPSIT?
- What are the design driving characteristics of the threats and situations that stress the Surface Navy TAD System and enable the evaluation of:
  - Ability to engage the threat;
  - Extent of the protected battlespace;

- Availability of the system;
- Training required to fight effectively;
- Risk of incorrect engagement decision; and
- Impact of force structure and operational concepts?

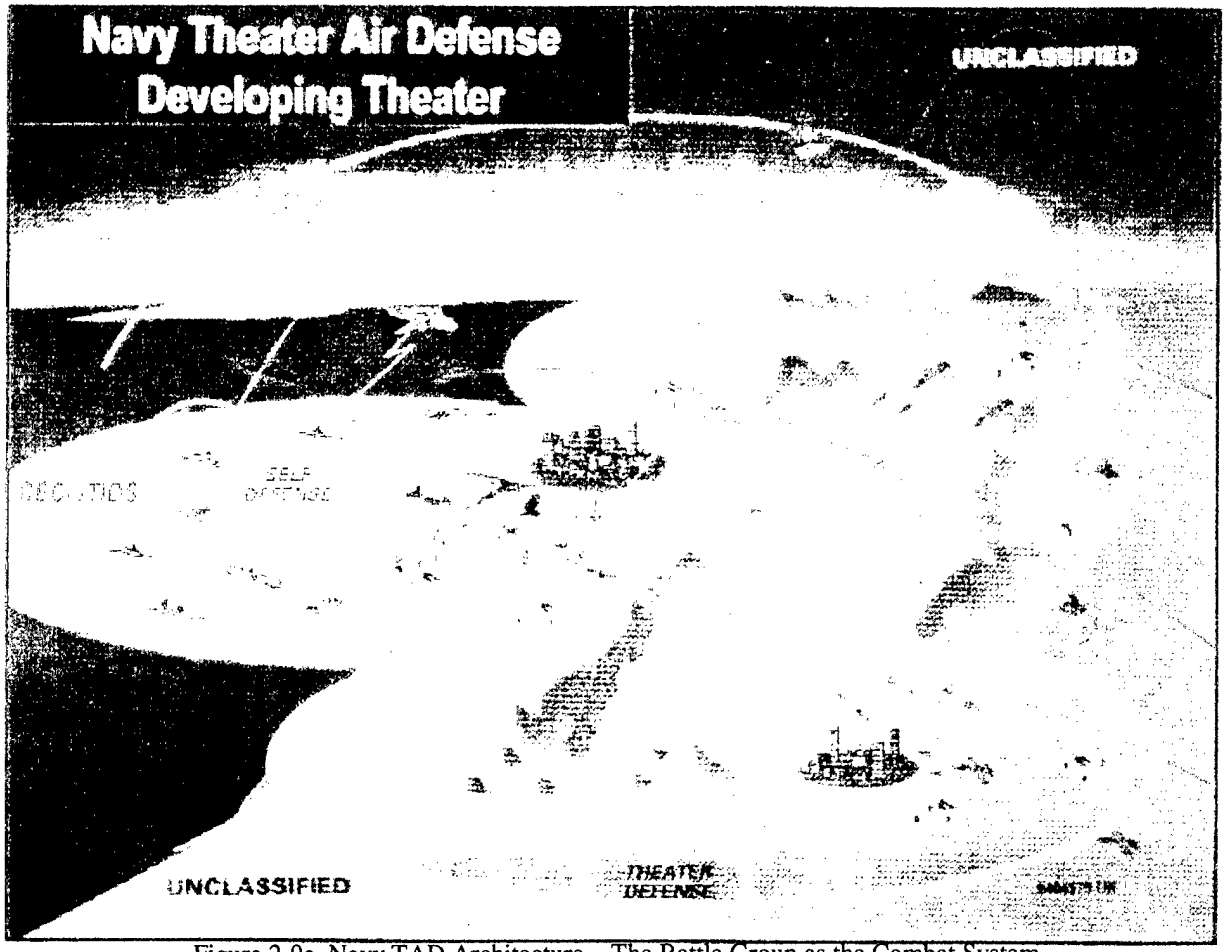



Figure 2-9a. Navy TAD Architecture—The Battle Group as the Combat System


Figure 2-9b. Navy TAD Architecture—The Battle Group
Combat System Full Joint Interoperability

Figure 2-10 shows the input to Step 1 and the process that will be executed to develop the outputs.

JHU/APL will lead the development of the DRM with major involvement by NSWCDD. Two Work Groups will be established to support the development of the DRM. The Engineering Work Group will be comprised of TAD analysis and design experts. The Engineering Work Group will be responsible for identifying the driving characteristics to adequately evaluate each aspect of the Surface Navy TAD System. The Operational Work Group, will include warfighters with experience in defining and executing the related TAD missions. The Operational Work Group will provide guidance and review of the CONOPs, ROEs and operational situations to ensure the DRM is truly representative of Naval and Joint Force evolutions. JHU/APL will be responsible for the coordination and passing of information from the Work Groups for incorporation into the DRM.

### 2.4.1 Step 1 Inputs

- Operational Requirements – An initial version of the Surface Navy TAD operational requirements being identified in Step 0 is required to properly reflect the mission of the system and develop the DRM.
- Elements from previously developed scenarios, DRMs and related program evaluations which are:
  - Mission Profile;
  - Force Structure;
  - Threats; and
  - Environment.
- Functional Descriptions - The definition of the top-level functions will be developed in Step 2 in parallel with the DRM definition. An understanding of the top-level functions is required to ensure that the proper characteristics are included in the DRM to evaluate all aspects of the system.

### 2.4.2 Review Existing Scenarios at the Theater, System and Element Level

The Defense Planning Guidance and Navy Planning Scenarios will be used as a basis to establish the general campaign objectives and description. Previously developed and approved operational situations and detailed engagement scenarios will be evaluated from recent or on-going TAD related COEA/AOAs such as TBMD and SSDS. Additional documentation such as the Littoral Warfare Handbook will be reviewed to identify scenarios which may by used to evaluate aspects of the Surface Navy TAD System not exercised by the situations in the COEA/AOA analyses.

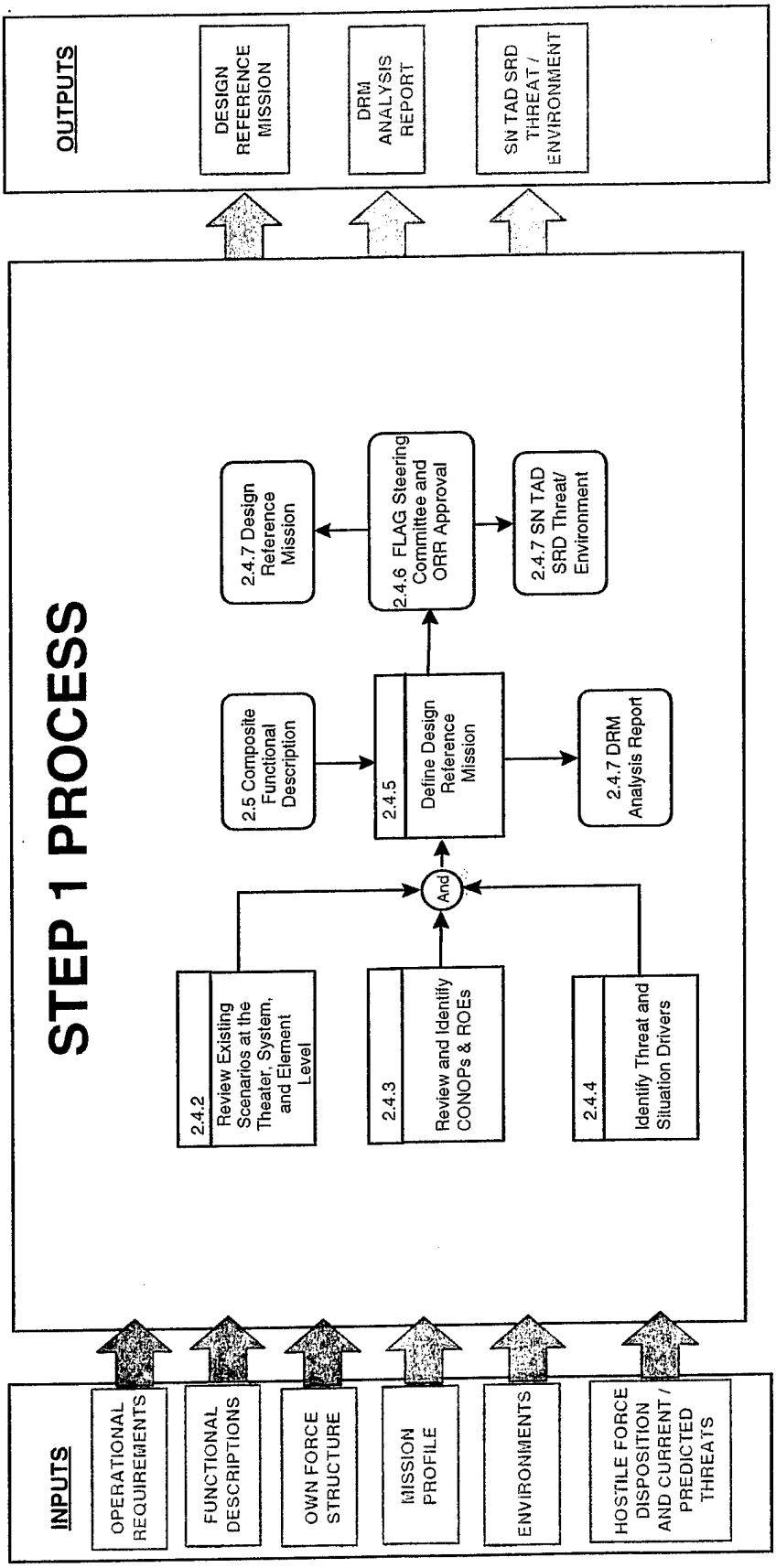



Figure 2-10. Define Operational Environment Process

2.4.3 Review and Identify CONOPs and ROEs

The recently developed Navy TAD CONOPs will be reviewed in the context of the scenarios identified in Section 2.4.2. The CONOPs for the relevant joint and non-Surface Navy TAD elements will be collected and reviewed. The required changes and additions to the CONOPs will be developed to describe the command and communication structures with sufficient detail to enable accurate modeling and analysis of the situations identified above. ROEs that have been utilized in the past during similar situations will be obtained for each of the general phases of the DRM from pre to post hostility and reviewed for possible variations. The Operational Work Group of warfighters and systems engineers with Surface Navy TAD experience will be utilized to provide guidance and review of the CONOPs and ROEs.

2.4.4 Identify Threat and Situation Drivers

The Engineering Work Group of TAD experts will review the OPSITs, CONOPs, ROEs and the threat documentation to determine the characteristics, which most significantly impact the overall performance of the Surface Navy TAD System. Once the Engineering Work Group has determined a preliminary set of system drivers, a correlation with the composite functional description of the system being developed in Step 2 will be performed. The purpose of the correlation is to determine if each of the top-level functions will be evaluated with the selected set of drivers. These performance drivers will be organized into logical groupings and quantifiable limits or boundaries will be documented. The Engineering Work Group will be led by JHU/APL and will consist of representatives shown in Table 1-1.

2.4.5 Define Design Reference Mission

The Surface Navy TAD DRM will be an expansion of the DRM that is currently being developed by JHU/APL. That DRM is being developed for the 2005 timeframe and focuses on the TBMD and OCMD missions. The Surface Navy TAD DRM will incorporate the appropriate additions and modifications to enable the evaluation of all aspects of TAD and extend the timeframe to 2015.

The goal of the DRM is to provide enough information to thoroughly define the full spectrum of Surface Navy TAD operational situations to enable accurate modeling without providing additional information that has little or no impact on the real world system performance. Incorporating factors that impact real world performance – factors that traditionally have not been incorporated in the analysis of individual systems – is the challenge in developing the DRM. Impacting factors to be considered include dynamic adversary response, reactive threats and timeliness of intelligence.

A single document will be developed which details the mission timeline, threat characteristics and OPSITs to adequately evaluate the Surface Navy TAD System in the context of a joint force campaign. The DRM will be put under interim configuration management after the internal review and full configuration management and control will be put in place following the ORR.

A DRM analysis report will be written which includes the details of the analysis performed and rationale used to develop the DRM. This report will also include sufficient traceability from approved originating documents to the various DRM components.

2.4.5.1 Threat Selection and Definition

A key characteristic of the DRM is the threat representation. For the Surface Navy TAD evaluation there are five basic types of threats that must be defined: theater ballistic missiles, overland cruise missiles, aircraft, anti-ship missiles (ASM), and guns/rockets. A DRM is currently being developed to evaluate TBMD and OCMD in the 2005 time frame with representative theater ballistic missiles and overland cruise missile threats. The ASM threats have been defined by ONR for previous PEO(TAD) and CNO evaluations. The TBM, Overland

Cruise Missile, and ASM threats will have to be evaluated to determine what modifications are required to project the definitions to 2015. This may require projections of the threat capabilities or a complete change or addition to the threats included in the set. The additional threat types, aircraft and guns/rockets, must be reviewed and representatives selected. The evaluation and selection process for all of the threat types must consider the likelihood of encountering the threat and the unique characteristics of the threat which stress the performance or functionality of the Surface Navy TAD System.

As the threats are selected for inclusion in the DRM, the available threat documentation must be reviewed by the Engineering Work Group to determine if the proper level of characterization is available. The level of characterization may vary significantly depending on the threat type and analysis tool used. For example the general sensitivity analysis performed in Step 3 with the force-on-force model will require far less detail than the engineering models that may be used for specific system level evaluations. The detailed characterization required includes but is not limited to: trajectory, radar and EO signature, countermeasures, and vulnerability to hard-kill and soft-kill. For those threats for which limited detail is available, the missing characteristics will be developed as required.

2.4.5.2 Mission and OPSIT Description

The 2005 DRM will be expanded and projected forward as required to incorporate additional 2015 Surface Navy TAD stressing features. The DRM will also include details on the force structure, ship deployment cycle and support system assumptions to enable evaluation of availability and maintainability.

The operational requirements and driver characteristics will serve as a crosscheck to ensure that the OPSITs encompass the bounds of TAD.

To provide a complete description, the DRM will contain information concerning all aspects of the campaign:

- Geopolitical Situation
- Overview of Adversary
- Overview of Joint Force
- Overview of Coalition Forces
- Campaign Phases and Timeline
- Detailed OPSITs

Each detailed OPSIT will provide the information required for modeling and simulation of the Surface Navy TAD System performance:

- Adversary Definition
  - Force Disposition
  - Threat Characteristics
  - Raid Composition
  - Counter Measures

- Joint Force Definition
  - Force Disposition
  - CONOPs and ROEs
- Neutral Definition
  - Background Air Traffic
  - Background Surface Traffic
- RF Environment
  - Background Emitter Environment
  - Electro-Magnetic Environment
- Natural Environment
  - Topography
  - Weather
  - Propagation Effects
  - Clutter

Variations or excursions will be defined in the DRM to enable the evaluation of system performance in both 2005 and 2015. The far-term, 2015, DRM variations will reflect changes in the threat characteristics and population and the introduction of new or improved own force assets.

2.4.6 Flag Steering Committee and Operational Requirements Review

A review of the draft DRM will be conducted with the members of both Work Groups and Surface Navy TAD management to obtain final comments and agreement on the content. After the Work Groups and Surface Navy TAD management comments are incorporated, the DRM will be presented to the TAD Flag Steering Committee for comments. The formal review and final approval of the DRM will not be performed until the Operational Requirements Review (ORR).

2.4.7 Step 1 Products

- Design Reference Mission - A single document will be developed which details the Mission Timeline, threat characteristics, operational situations and the required excursions to adequately evaluate the Surface Navy TAD System in the context of a Joint Force campaign. The DRM will be put under interim configuration management after the internal review and full configuration management and control will be put in place following the ORR;
- Surface Navy TAD SRD Threat/Environment - At the completion of Step 1, threat and environment information will be incorporated into the SRD. This will summarize the DRM developed under this task and will reflect the threats that the Surface Navy TAD "system of systems" will address and the environment in which the Surface Navy TAD System will operate; and a
- DRM Analysis Report - This report will include the details of the analysis performed and rationale used to develop the DRM. This report will also include sufficient traceability from approved originating documents to the various DRM components.

## 2.5 STEP 2 - DEFINE SYSTEM BOUNDARIES

The intent of this step in the system requirements engineering process is to describe the functions to be performed by Surface Navy TAD and the boundaries and interrelationships of Surface Navy TAD and its subsystems (or elements) with other Joint Theater Air Warfare Systems. It will address both the internal and external Surface Navy TAD functional interfaces and relationships, and it will document the sensitivity of current Surface Navy TAD performance to external interfaces and information flow. See Figure 2-11 for a pictorial of Surface Navy TAD System boundaries. The Surface Navy TAD System is in the middle box with external interfaces depicted around it.

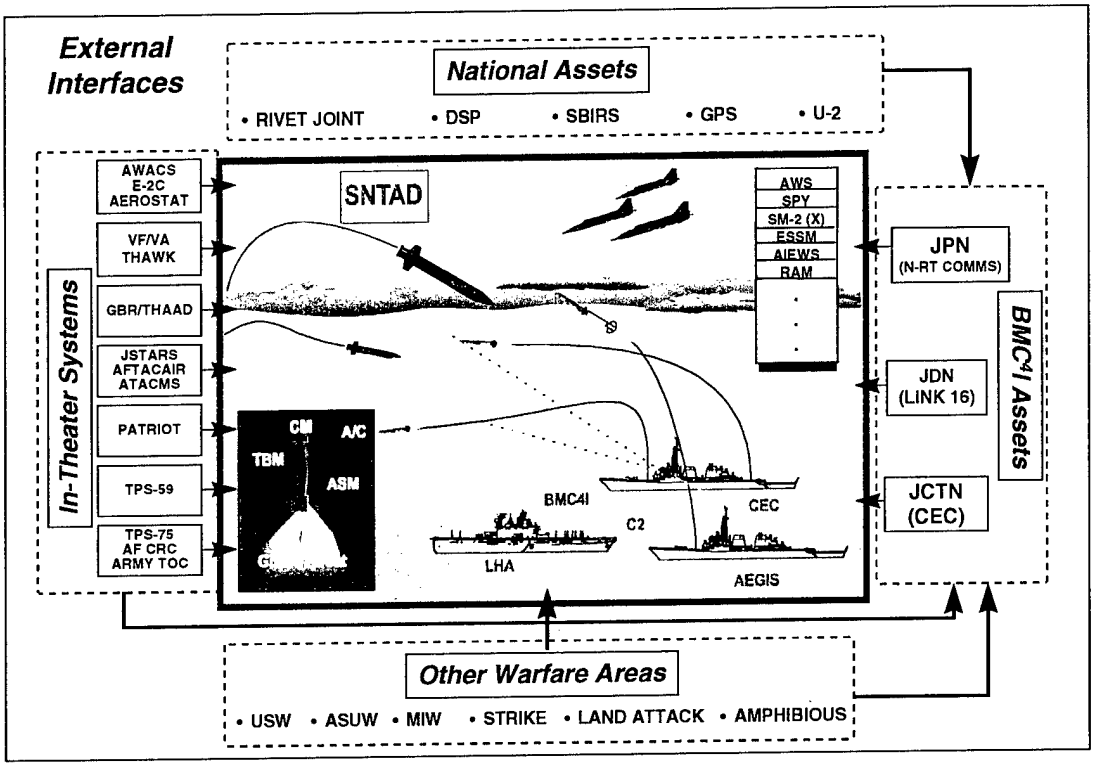



Figure 2-11. Surface Navy TAD System Boundaries

At this stage of the engineering process the intent is: (1) to understand the functionality and performance characteristics and the physical and functional relationships between current Surface Navy TAD subsystems; (2) to understand and document the interfaces and functional interrelationships between Surface Navy TAD and other Joint TAD related systems; (3) to understand and document the functionality and functional relationships needed to implement currently planned initiatives and (4) to understand and document any additional functionality needed to meet the total set of operational requirements defined in Step 0. In the context of this task, the term current will include near term and funded improvements and developments.

A major product of this task will be a hierarchical functional description of current Surface Navy TAD embedded in a systems engineering tool database. The database will include functional descriptions, intra and intersystem interfaces, boundaries and functional flow diagrams. Functions performed by interfacing systems will also be included when they impact on the conduct of Surface Navy TAD. The database will also include key Surface Navy TAD related performance characteristics of current Surface Navy TAD subsystems. This database will then be extended to include the functionality of planned new initiatives and any additional functionality required to meet the requirements of Step 0. This "composite functional

description" will provide the basis for identifying functions not currently being performed by existing systems and to the development of system alternatives to be performed in Step 4. It will also be an input to the identification of key attributes in Step 3.

Figure 2-12 provides an overview of the system requirements engineering processes to be carried out in Step 2. This step is intended to answer the following questions:

- What are the boundaries of the Surface Navy TAD System as it currently exists?
- What are the subsystems that make up the current system and what functions do they perform? What are their key performance characteristics? In the context of this effort the term "current system" includes near term systems that are currently under development.
- What are the current Surface Navy TAD System internal and external interface requirements and characteristics?
- What are the current interface and database standards that govern multiple Surface Navy TAD subsystems?
- What is the functionality and performance of planned new initiatives such as the Volume Search Radar (VSR), Multi-Functional Radar (MFR) and Sea Athena?
- What are the composite set of functions that Surface Navy TAD of the year 2015 must perform?
- What are the relationships and interfaces between those functions?

This step will be led by JHU/APL with support from NSWCDD, Surface Navy TAD subsystem system engineers and other participants as defined in Table 1-1.

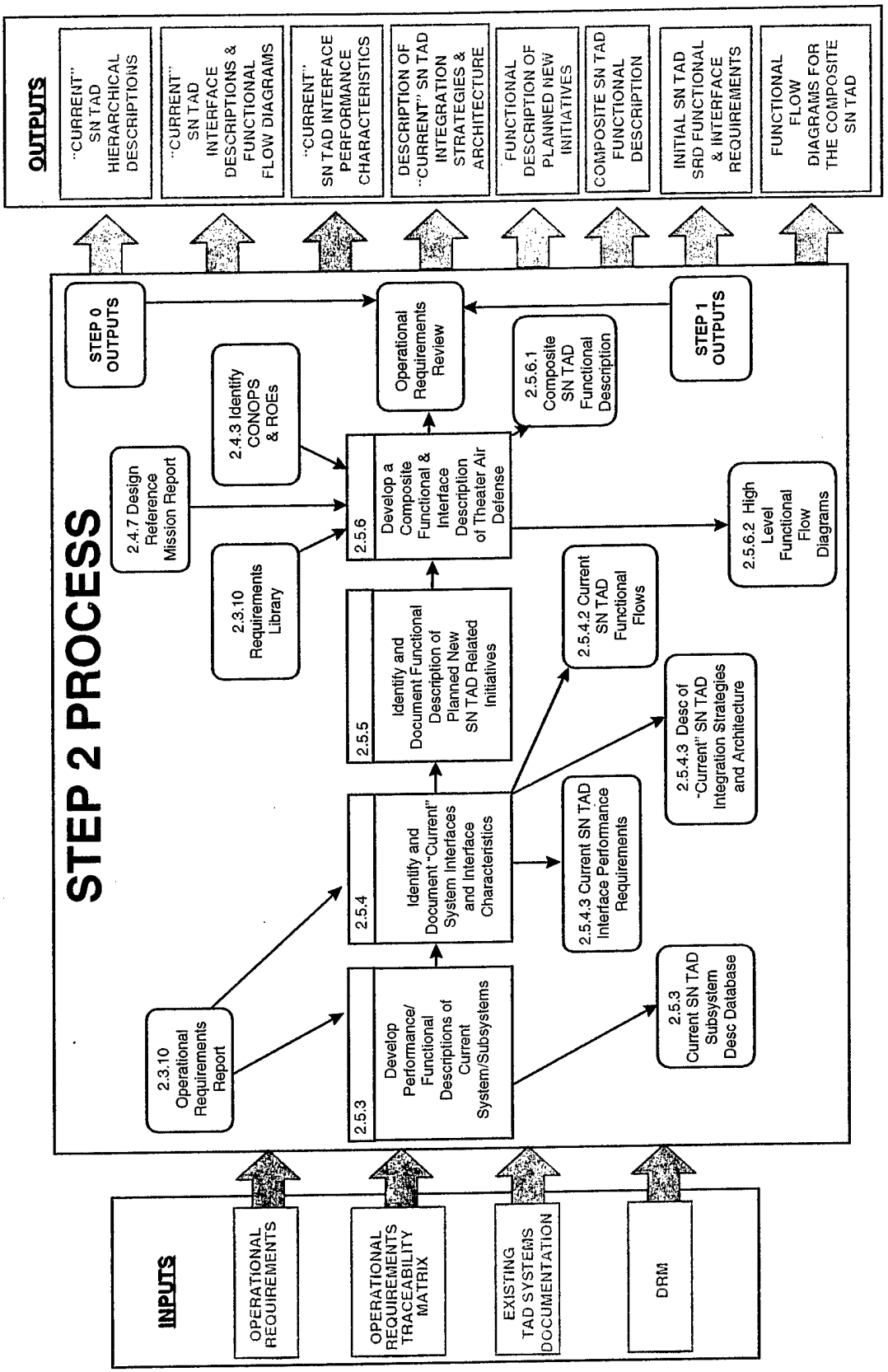



Figure 2-12. Define System Boundaries Process

2.5.1 Step 2 Inputs

As depicted in Figure 2-12, the major inputs to this task are as follows:

- Operational Requirements Report from Step 0;
- Operational Requirements Traceability Matrix from Step 0;
- Current Nomenclatured System Specifications and Descriptions; and
- DRM from Step 1.

2.5.2 Systems to be Addressed

This task will address all systems that play either a direct or significant indirect role in Surface Navy TAD. Many of the individual systems that comprise Surface Navy TAD support other non-Theater Air Defense functions. These non-TAD functions contribute to the environment in which TAD is conducted and in many cases compete for resources with the carrying out of TAD. To the degree that these functions impact TAD they will be included as part of this system requirements engineering effort. Likewise, all interfacing systems that could substantially impact Surface Navy TAD will be addressed. All systems will be characterized in the Surface Navy TAD database as to the higher level systems of which they may be considered a part. Shipboard systems to be addressed in this task are listed in Table 2-1. Non-shipboard systems to be addressed are given in Table 2-2.

2.5.3 Develop Descriptions of Current Surface Navy TAD System and Subsystems

2.5.3.1 Develop Functional Descriptions of Nomenclatured Surface Navy TAD Subsystems

The objective of this substep is to produce a functional description of Surface Navy TAD and its constituent elements. A database that contains hierarchical functional definitions of the current systems that are elements of Surface Navy TAD will be developed. These functional descriptions can be drawn largely from existing system documentation. The functional decomposition will only go to that level required to clearly articulate the role that each nomenclatured system plays in overall TAD and to understand the relationships between these subsystems of Surface Navy TAD. The database will also contain linkages between the operational requirements documented in Step 0 and the functions performed by the individual systems that make up Surface Navy TAD.

To ensure that the functionality of current Surface Navy TAD subsystems are captured, representatives from the nomenclatured system technical community will participate in the development of the functional descriptions. A series of Work Groups made up of NSWCDD, JHU/APL and TAD systems engineering personnel and representatives from the nomenclatured system under consideration will be utilized to ensure both a consistency of approach and depth and accurate capturing of system functionality.

2.5.3.2 Determine and Document Current Surface Navy TAD Subsystem Performance Characteristics

The individual Surface Navy TAD nomenclatured subsystems performance characteristics will be abstracted from existing documentation and inserted in the database. These performance characteristics will be expressed relative to the functions that are being performed by the subsystem being addressed. Emphasis will be on those characteristics that are visible to other elements of Surface Navy TAD and that impact overall Surface Navy TAD performance. In addition to these performance characteristics, key compatibility and interoperability characteristics will also be abstracted and added to the database.

2.5.4 Identify and Document Current System Interfaces and Characteristics

This section addresses the functional definition of the interfaces between Surface Navy TAD subsystems and between Surface Navy TAD and non-Surface Navy TAD systems as well as the strategy and architecture used to integrate the various Surface Navy TAD subsystems. This section has three main elements:

- The identification of external interfaces and the addition of interfacing systems to the functional database;
- The addition of functional interface information to the database;
- The identification of key performance characteristics for current interfaces that are potential "stress" points in terms of performance; and
- The documentation of the current interface architectures and strategies used in Surface Navy TAD.

2.5.4.1 Develop Functional Descriptions of Systems that Interface to Surface Navy TAD

External interfaces will be identified and the functional database built in the proceeding section will be expanded to include those Navy and non-Navy systems that support and interface with the systems that make-up Surface Navy TAD. The emphasis will be placed on those aspects of these interfacing systems that contribute to TADe and which compete for resources that are used in conducting TAD. In addition, the relationship of interfacing systems to higher level nomenclatured and "virtual systems" will be identified and included in the database.

2.5.4.2 Develop Functional Interface Descriptions and Functional Flow Diagrams

Functional interface descriptions and functional flow information will be added to the database developed that was expanded under Section 2.5.3. The database will link the interface data flow to originating and receiving subfunctions as well as originating and receiving elements. The database will include both intra-Surface Navy TAD interfaces and interfaces to non-TAD systems. The database will be used for interface and functional analysis.

The primary source documents for developing this extension to the database will be current interface requirements specifications, interface design specifications and interface documents. The objective of the definition is to abstract the functional interface definition from the source information and not to enter all the individual message definitions into the database.

2.5.4.3 Identify Key Interface Performance Characteristics of the Current Surface Navy TAD System and Nomenclatured Subsystems

Using current nomenclatured system descriptions and interface documentation, an interface analysis report will be developed that identifies key interface requirements. Interface characteristics that stress or significantly impact system performance (such as data link reporting latency) will be identified and included in the database. An analysis will be conducted to identify situations where a function in one subsystem is closely coupled to a function in another subfunction and that function is sensitive to changes in the interface or implementation of the interfacing function. These areas will be documented for subsequent analysis in Step 4.

2.5.4.4 Identify Current Integration Strategies and Architecture(s) Used for Surface Navy TAD

This section focuses on the methodology used to integrate the various elements of Surface Navy TAD with each other and with outside systems. The objective of this section is to develop an understanding of the current integration strategies being used and their implications on interoperability, life cycle cost and system performance. A report describing the overall architecture(s) and strategy used to integrate the current subsystems that make up Surface Navy TAD will be produced. Where different ship classes use different approaches to integrate similar elements and functions, the benefits of migrating to a common approach shall be

assessed. Current interoperability and interface standards and protocols that govern interfaces across Surface Navy TAD System and subsystem boundaries will be identified. These shall include such items as intercomputer interface protocols, data link standards, ID taxonomies used by command and control systems, etc. When practical, existing documentation will be summarized and referenced rather than generating new descriptions. Potential system bottlenecks resulting from interfacing architecture or techniques that may impact overall Surface Navy TAD performance will be identified. Databases that are used by more than one subsystem shall also be identified and documented.

2.5.5 Develop a Functional Description of Planned New Surface Navy TAD Related Initiatives

The functional and interface descriptions developed in Sections 2.5.3 and 2.5.4 will be expanded to include all planned new Surface Navy TAD subsystem initiatives. Examples of these new initiatives include the new Multifunctional Radar, the new Volume Search Radar and Sea Athena.

2.5.6 Develop a Composite Functional and Interface Description of FY 2015 Surface Navy Theater Air Defense

Utilizing the information generated in Sections 2.5.3, 2.5.4 and 2.5.5 along with additional information from the requirements documented in Step 0 and the Design Reference Mission developed in Step 1, a Composite Functional Description of Surface Navy TAD will be developed. The description will include hierarchical descriptions of the functions to be performed, functional flow diagrams, and a description of external interfaces.

2.5.6.1 Expand the Current Surface Navy TAD Functional Description

The functional decomposition developed in Section 2.5.3.1 will form the basis of the composite Surface Navy TAD functional description. This functional description will be expanded as required based on the Operational Requirements Traceability Matrix of Step 0 and the DRM developed in Step 1. Each operational requirement captured in Step 0 will be analyzed and traced to the top-level function or functions required to implement that requirement. New functions will be generated when the current functional descriptions inadequately capture the requirements. Likewise, the DRMs generated in Step 1 will be used to ensure that all mission requirements have been captured in the Composite Functional Description. The level of functional decomposition used in describing the current Surface Navy TAD systems will be used as a guide to decomposition of any new functions. The top-level functions will be decomposed to an appropriate level: 1) to perform trade studies, 2) do performance modeling and 3) conduct functional allocation to the nomenclatured systems in latter steps of the Surface Navy TAD system requirements engineering process. All functions and subfunctions will be identified in the database as a new function or subfunction or one currently performed by a subsystem of Surface Navy TAD or an interfacing system. Areas of functional overlap and functional duplication by current subsystems will be identified for further analysis in Step 4. Traceability to current systems and operational requirements will be documented.

2.5.6.2 Develop Surface Navy TAD System Functional Flow Diagrams and External Interface Descriptions

Functional interface descriptions will be added to the functional description database developed in the preceding section. The database will link the interface data flow to originating and receiving subfunctions. This expanded database will include both intra-Surface Navy TAD interfaces and interfaces to non-TAD systems. Where new functional requirements require new interfaces or additional information to flow between functions, they will be added to the functional interface description. The database will capture the rationale for these new interfaces and interface requirements and the database will flag these interface requirements as being newly derived requirements. The database will be used to generate functional flow diagrams and a description of interfaces to external systems. This composite functional interface description will facilitate the functional allocation to be done in Step 4.

2.5.6.3 Update Functional and Interface Description Based on Steps 3 and 4

It is anticipated that the composite functional and interface description will be modified after Steps 3 and 4 as functions are restated and repartitioned to better reflect the need for the allocation of performance to functions and subfunctions and functions and subfunctions to subsystems.

2.5.7 Step 2 Products

The following products will be produced by this task and will be reviewed at the Operational Requirements Review:

- Current Surface Navy TAD Hierarchical Functional Descriptions;
- Current Surface Navy TAD Interface Descriptions and Functional Flow Diagrams;
- Current Surface Navy TAD Interface Performance Characteristics;
- Description of Current Surface Navy TAD Integration Strategies and Architecture;
- List and brief description of current interface standards and protocols that govern interfaces across system boundaries;
- List and brief description of databases used by more than one Surface Navy TAD subsystem;
- Functional Description of Planned New Initiatives;
- Composite Surface Navy TAD Functional Description;
- Initial Draft of the Functional and Interface Requirements for the SRD; and
- Functional Flow Diagrams for the Composite Surface Navy TAD System Including Interfaces and Functional Relationships to Pertinent Non-Surface Navy TAD Systems.

The products of this step and those of Steps 0 and 1 will be reviewed at the ORR.

## 2.6 STEP 3 - IDENTIFY SYSTEM/SUBSYSTEM ATTRIBUTES THAT SUPPORT HIGHER LEVEL SYSTEMS

The objective of this phase is to identify the key 2015 Surface Navy TAD system and subsystem attributes that are fundamental to the successful completion of the Surface Navy TAD mission and to translate these findings into a CPB comprised of top-level functional and performance requirements for Surface Navy TAD.

Step 3 is designed to identify the critical 2015 Surface Navy TAD functions and their key attributes that contribute to warfighting success and to begin the iterative process necessary to incorporate risk and affordability into the CPB. This process will utilize a combination of warfighter, decision maker and technical experts coupled with parametric analyses. Figure 2-13 shows that a balance of cost, schedule and performance are important considerations in defining Surface Navy TAD requirements and capabilities.

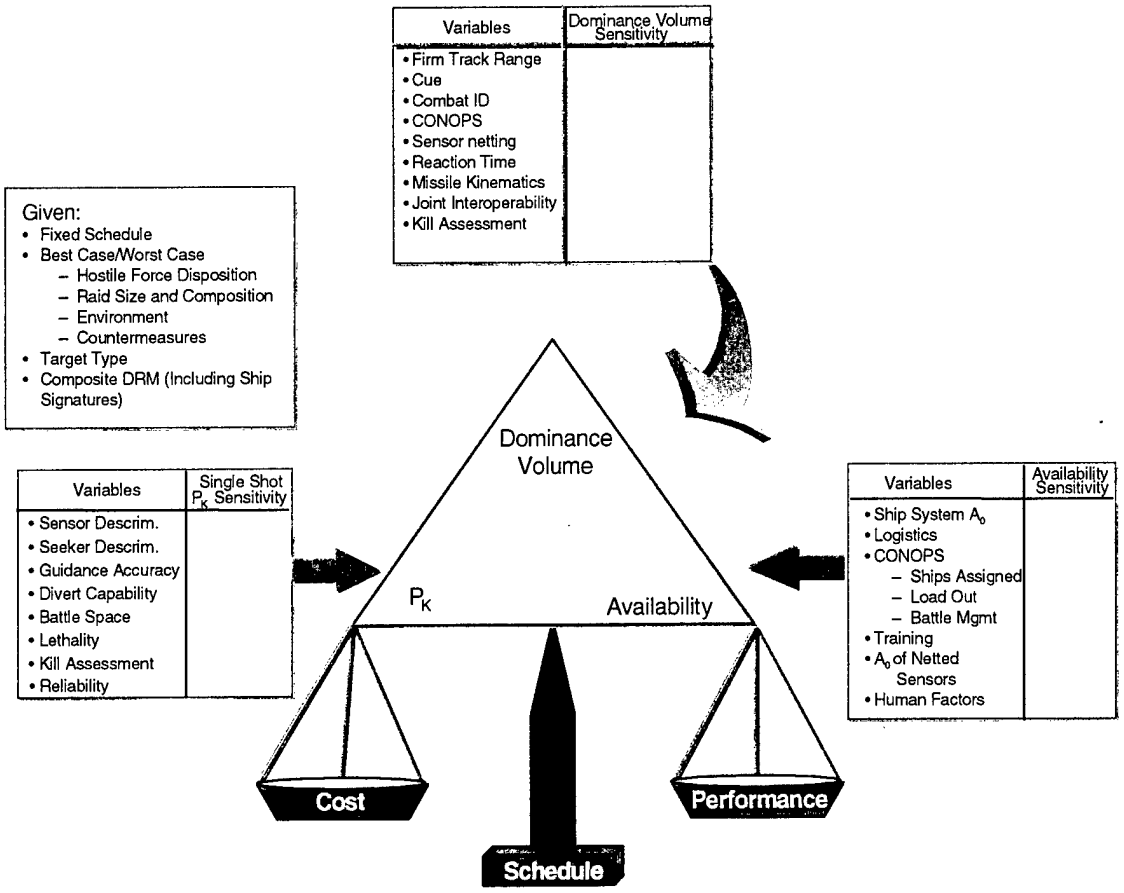



Figure 2-13. Surface Navy TAD Candidate Key Attributes

The CPB developed in this step will be used in Step 4 to establish the Surface Navy TAD Functional and Allocated Baselines, including the functional and performance requirements for Surface Navy TAD subsystems (nomenclatured systems). Figure 2-14 shows the process required to develop the CPB.

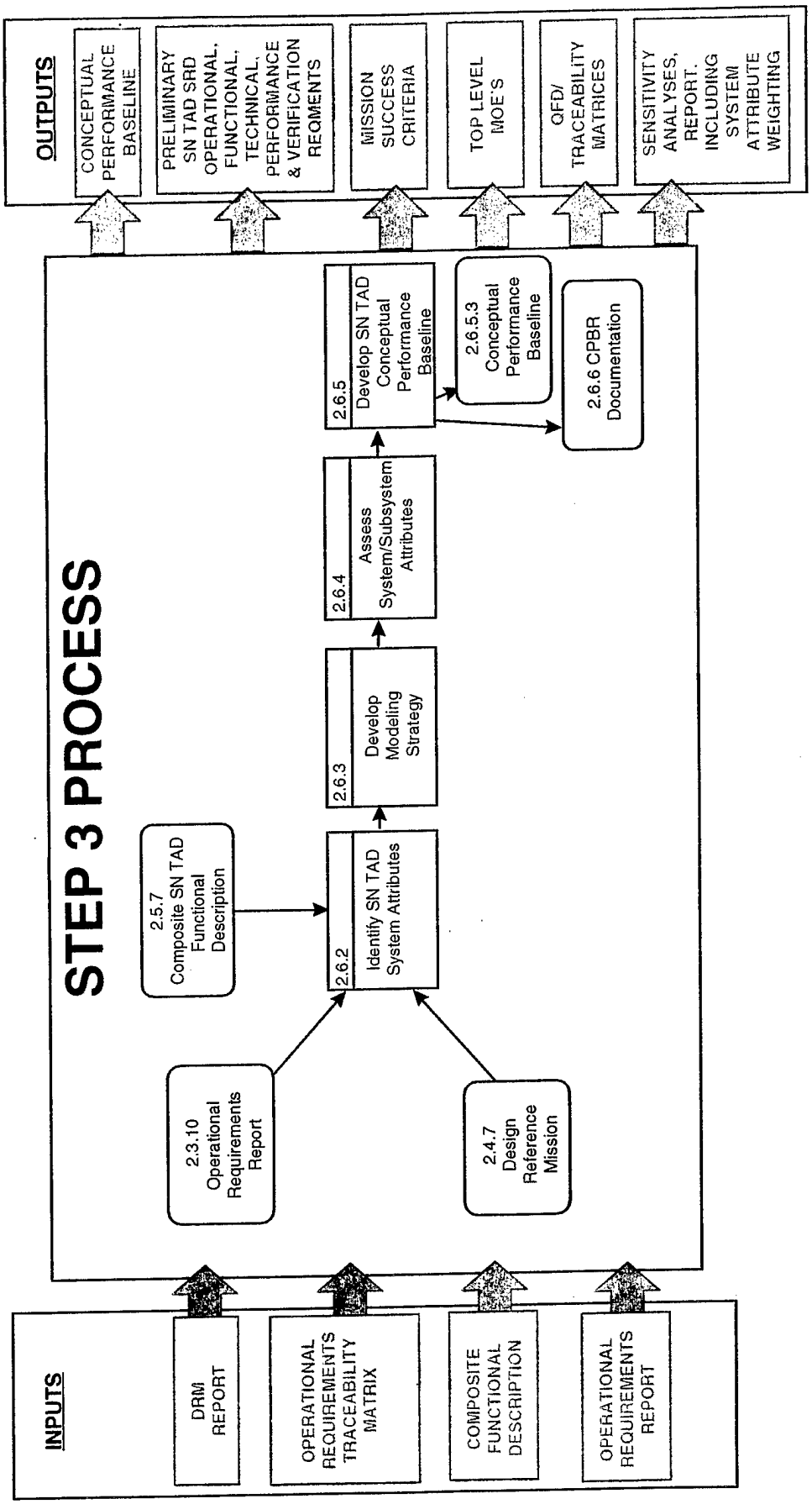



Figure 2-14. ID System/Subsystem Attributes Process

Key questions this step is designed to answer include:

- What are the critical Surface Navy TAD mission success criteria?
- What are the key attributes and associated performance measures of the Surface Navy TAD critical functions?
- How do potential affordability constraints affect Surface Navy TAD mission success?
- What are the top-level Surface Navy TAD system functional and performance requirements which are critical to ensure that the mission success criteria are met?

### 2.6.1 Step 3 Inputs

As shown in Figure 2-14, Step 3 requires several key inputs from previous steps. These inputs include:

- Operational Requirements Traceability Matrix - The Operational Requirements Traceability Matrix, generated in Step 0, will provide the starting point to begin the requirements iteration process;
- Operational Requirements Report - The Operational Requirements Report generated in Step 0 documents requirements issues and their resolution;
- Design Reference Mission Report - The 2015 Design Reference Mission developed in Step 1 provides the design stressing composite scenarios to be used in analyses identifying critical functions and key attributes; and
- Composite Functional Description - The Composite Functional Description of Surface Navy TAD developed in Step 2 will provide the basis from which critical functions and their attributes will be identified.

### 2.6.2 Identify Surface Navy TAD System Attributes

#### 2.6.2.1 Surface Navy TAD System Level Attributes and Mission Success Criteria

System level functions and attributes which are critical to the Surface Navy TAD mission success will be identified early in the process. Although more rigorous and expensive approaches (i.e. war games or war game simulations) could be used, the initial plan is to utilize the wealth of expertise within the Navy and other services to help narrow the scope of analyses which must be conducted. Through a structured brainstorming approach, utilizing Quality Functional Deployment (QFD) techniques described below, these most critical system level functions and attributes will be identified and agreed upon by a work group composed of system engineers, warfighters and decision makers within the Joint TAD arena. This process provides a key entry point for warfighters and decision makers to impact the requirements refinement process early in the systems engineering cycle. During this QFD process, the Work Group participants will draw heavily on the previously developed top-level requirements and functional descriptions developed in Steps 0 and 2. The critical functions and attributes identified by this process will be used to define and guide more detailed parametric analyses. This top down process will also serve as a check on the functional descriptions developed in Step 2 to ensure that all critical functions have been identified.

#### 2.6.2.2 Step 3 Work Group Participants

Where possible, Work Group participants who supported the Requirements Work Group in Step 0 will also support the Step 3 Work Group. The Work Group will be co-led by JHU/APL and NSWCDD and supported by representatives listed in Table 1-1.

2.6.2.3 Key System Level Attributes

The QFD process envisioned is very similar to the process utilized by the Joint Advanced Strike Technology Program (JAST). A QFD analysis is nothing more than a structured process designed to facilitate the decomposition of a difficult problem into several smaller, but more easily understood problems. The process is documented via a series of matrices in Figure 2-15. In the QFD process a series of "WHATs" (objectives to be accomplished) are identified and listed in the first column of the matrix. Then a series of "HOWs" (the means by which the objectives are to be accomplished) are identified and placed along the top row of the matrix. The strength of the relationship between the "HOW" and the "WHAT" is rated based on a strong, are then assigned the numerical values of 9, 3 or 1 respectively. A weighted score is then calculated to determine the relative importance of each "HOW" in meeting the collection of "WHATs."

The process is then repeated in the next lower tier by making the "HOWs" from the higher level matrix become the "WHATs" of the next lower tier and then repeating the process by identifying a new set of "HOWs". Utilizing this approach the QFD participants will establish a set of matrices, Figure 2-16. The first tier matrix will identify campaign objectives (WHATs) versus Surface Navy TAD objectives (HOWs). The second tier matrix will be Surface Navy TAD Objectives (WHATs) versus Surface Navy TAD operational tasks. The third tier matrix will be Surface Navy TAD operational tasks (WHATs) versus critical Surface Navy TAD functions (HOWs). The fourth tier matrix will be Surface Navy TAD functions (WHATs) versus attributes (HOWs). Through this process the mission success criteria, top-level performance measures, critical objectives, mission critical functions and associated attributes will be determined from the warfighter's perspective.

This information, coupled with the Composite Functional Description provided in Step 2, will be used to structure and guide more detailed analyses described below.

2.6.2.4 Key System Level Cost Attributes

The Surface Navy TAD system/subsystem attributes address the critical descriptors of system cost. These attributes must be defined in terms of underlying drivers and, if possible, related to the performance attributes. Once described, the attribute data must be collected for the current system.

2.6.2.5 Document Results

The results of the QFD analysis will be documented in a series of matrices described above. In addition a more detailed explanation of the results, deliberations and rationale will be documented as part of the Surface Navy TAD System Attribute and Success Criteria Report.

2.6.3 Develop Modeling Strategy and Alternatives

Prior to beginning sensitivity analysis a modeling strategy must be developed for both performance and cost models, including identification of the most appropriate models or level of models. Assessments will be made at the appropriate time to determine which existing models would meet the minimum requirements for the respective aspect of the analysis. A spectrum of models will be needed to address the entire system as well as critical functions and attributes (i.e., different levels of detail). However, for this step the force-on-force level model is of prime interest. Step 4 will require extensive use of engineering level models, as well as force-on-force, and these will be addressed in Section 2.7 of this plan. The force-on-force model's acceptance in the joint services community is critical to the acceptance of the analysis results.

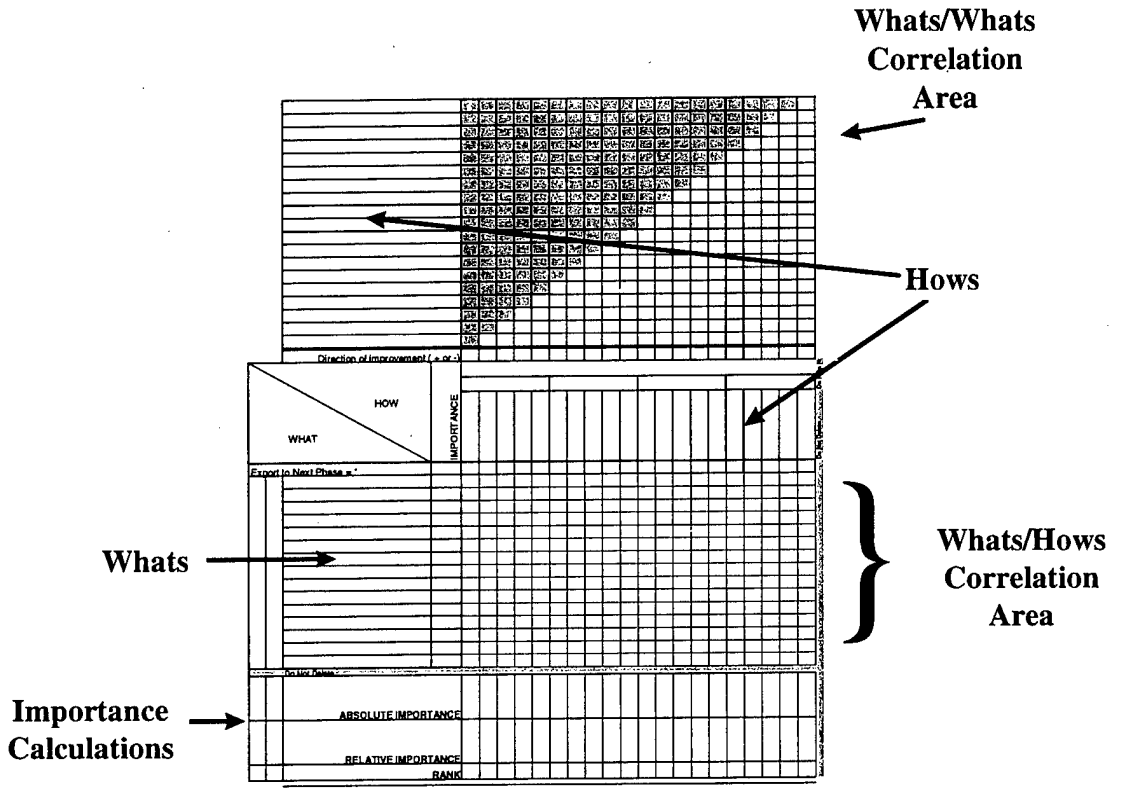



Figure 2-16. The QFD Matrix

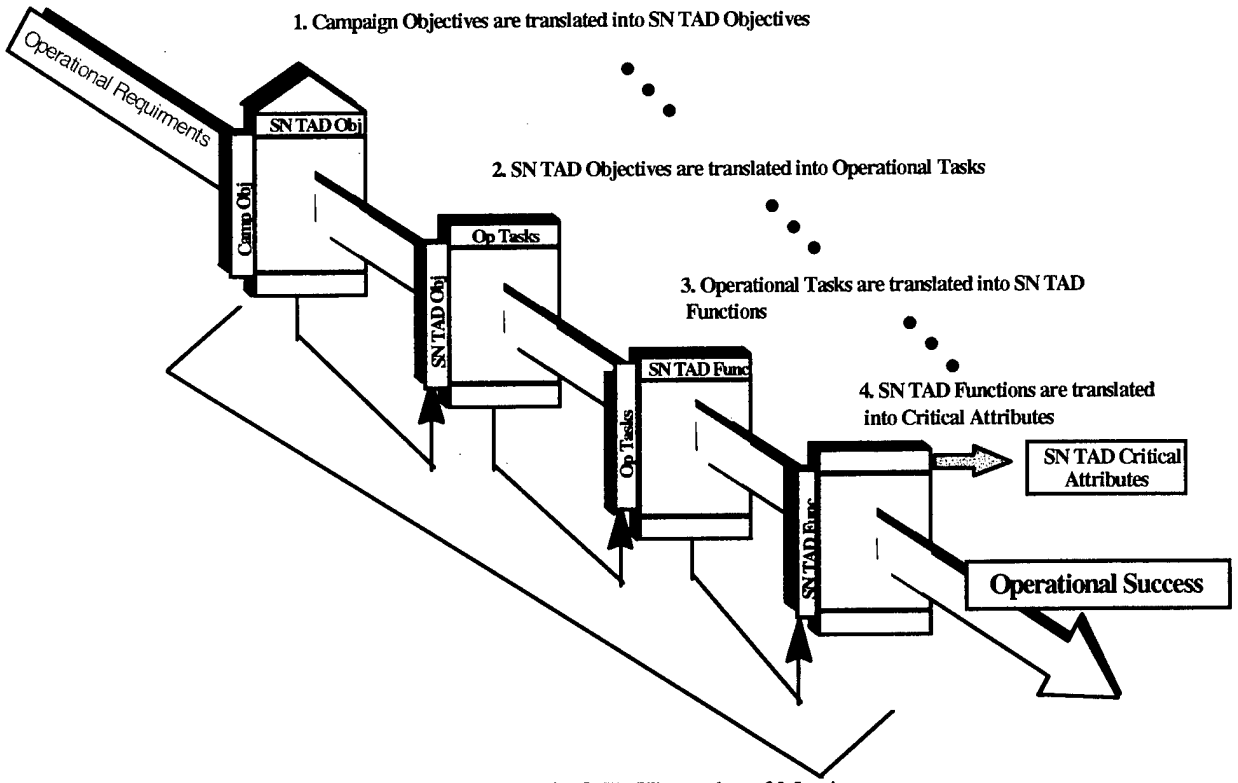



Figure 2-16. QFD Hierarchy of Matrices

2.6.3.1 Model Availability/Suitability

Many detailed models of the nomenclature Surface Navy TAD subsystems exist and a selected subset will be used in Step 4. However there are very few models capable of the sensitivity analyses at the Surface Navy TAD system of systems level required for this task. In particular, conventional models may not exist for some of the critical functions and attributes identified in the QFD analysis above. The Extended Air Defense Test Bed,(EADTB) and the Extended Air Defense Simulation (EADSIM) are force-on-force models developed specifically for this type of analysis. Other models of this general type are Generalized Campaign Analysis Model (GCAM), Multi-Warfare Assessment and Research System (MARS) and Navy Simulation System (NSS). It presently appears that EADTB is the most flexible and all encompassing force-on-force model to be used in pursuit of key "system of systems" performance measures. However, the full scope of EADTB's potential can not be addressed at this time. Other alternatives to augment as necessary include EADSIM and less comprehensive force models.

2.6.3.2 Modeling and Simulation Data Requirements

There may be unique data required for the sensitivity analyses. For EADTB, much of this is within the domain of the Specific System Representation (SSR) to be developed during the execution of this plan by specific Surface Navy TAD subject matter experts and will not require modifications to the force-on-force model. Exact data requirements will not be developed in this plan. However, work will be initiated at project start to further populate EADTB with the required subsystem level of SSRs for Surface Navy TAD.

2.6.4 Assess System and Subsystem Attributes

The task of assessing the sensitivity of Surface Navy TAD mission success criteria and top-level measures of effectiveness to key system attributes and subsystem functions and attributes will be based on:

- The Surface Navy TAD mission success criteria, top-level performance measures and critical attributes;
- The 2015 Design Reference Mission; and
- The Surface Navy TAD Composite Functional Description and critical interfaces.

Using modeling strategy in Section 2.6.3, key system attributes and critical functions will be determined through analyses. The results of these analyses will be compiled into a Sensitivity Analyses Report documenting the parameters analyzed, the specific DRM OPSITs selected, the models and databases used and the results. This package will form a basis for developing the Surface Navy TAD CPB.

2.6.4.1 Sensitivity Analysis Matrix

The matrix of system level functions and their attributes developed in the QFD process will be used to develop a sensitivity analysis matrix. The values of the lower level attributes will be varied parametrically in order to assess the sensitivity of higher level functions to these attributes. This analysis matrix will be reviewed by the QFD participants to ensure validity and appropriateness. The numerical ranking of the functions and attributes from the QFD process will be used to reduce the number of possible combinations of parameters that must be analyzed.

2.6.4.2 Composite Functional Description to Model Map

The Composite Functional Description prepared in Step 2 will be mapped to the system representation used in the analysis models. The objective of this mapping process is to clearly understand how each of the Surface Navy TAD functions is represented within the model. Many of these functions will be explicitly represented. However, many may be hidden in assumptions of represented implicitly within the model.

2.6.4.3 Sensitivity Analyses

Selected models will provide sensitivity analyses based on the DRM and will be run in accordance with the Sensitivity Analysis Matrix and Composite Functional Description mapping discussed above. Sufficient numbers of runs will be conducted to ensure result validity. For the most promising parameter sets evaluated a corresponding rough order of magnitude life cycle cost estimates will be developed so that some measure of cost versus performance can be assessed. The process will be reiterated with adjustments made to the parameter set in order to obtain cost/performance sensitivities. System attributes will be prioritized and given weightings. The system attribute weightings will identify the key system attributes and critical functions which are deemed most important in their contribution to the overall success of the mission. The final result will be a process derived set of Surface Navy TAD functional and performance requirements within affordability constraints provided by the Operational Requirements Report generated in Step 0. More refined cost analyses will be completed in Step 4 and the iteration loop exercised again once the functional allocations have been made at the subsystem level. Results of the sensitivity analyses, as well as the system attribute weightings, will be included in the Sensitivity Analyses Report.

2.6.5 Top Level Surface Navy TAD System Conceptual Performance Baseline

Once the sensitivity analyses have been completed, several steps will still be required prior to finalizing the system level CPB. The derived functional and performance requirements must be reconciled with previously stated requirements determined from earlier steps in this plan. CPB options must be developed offering alternatives based on technical and warfighting risks. Finally, a Conceptual Performance Baseline Review (CPBR) will be held to review the CPB options and finalize the CPB.

2.6.5.1 Requirements Reconciliation

Requirements reconciliation will require an iterative process of comparing the derived functional and performance requirements with stated requirements defined in Step 0 and with the Composite Functional Description developed in Step 2. In addition, significant variances between the required performance levels and the affordability constrained performance levels must be reconciled where they exist. Once these variances are reconciled, CPB options can be developed based on the remaining primary issues of risk and affordability.

2.6.5.2 CPB Options

Once the derived functional and performance requirements are reconciled, CPB options will be identified and will include verification methodology. A risk assessment will be performed specifying when certain warfighting capabilities are required along with the cost necessary to support those capabilities. Technical and warfighting risks will then be determined due to the impact of not having certain warfighting capabilities developed at certain times. Detailed risk management plans will not be developed at this time. The objective of the risk assessment is to determine if unacceptable warfighting risks are incurred with cost driven solutions or if alternative tactics might be employed to mitigate these risks. The risk assessment process is very subjective and may entail the use of various analysis techniques such as what-if

scenarios, probability distributions and correlation matrices, all of which can be managed by a risk assessment tool. CPB options will be based on the risk assessment and will be ranked indicative of the likelihood of mission success by a consensus among the Step 3 Work Group members.

2.6.5.3 Conceptual Performance Baseline Review and Documentation

CPB options will be reviewed with the TAD Flag Steering Committee to assist in finalizing recommendations for the CPB. A formal review of the recommendation, supporting data and rationale will then be conducted. The Conceptual Performance Baseline Review team will be led by PEO(TAD)-SE and include selected personnel shown in Table 1-1. The CPBR will be coordinated by JHU/APL and NSWCDD.

The final CPB documentation will be modified, if necessary, based on the results of the CPBR. The CPB will include key system attributes associated with each critical functional, performance level required for each attribute, and acceptable cost goals. It will define the agreed upon functional, performance, cost and warfighting capability requirements for Surface Navy TAD. The CPB will be placed under interim configuration control upon approval by the Flag Steering Committee and full configuration control after CPBR approval. Once the CPB is placed under full configuration control, the Operational Requirements Traceability Matrix and Composite Functional Description will be updated.

The CPB will form the basis for the preliminary Surface Navy TAD SRD sections reflecting functional, performance and verification requirements. Also, the Surface Navy TAD mission program operational requirements updated by this step will be documented in preliminary sections of the SRD.

2.6.6 Step 3 Products

The following products will be produced by this step:

- Conceptual Performance Baseline;
- Preliminary Versions of the Operational Requirements, Functional Requirements, Technical Performance and Verification Requirements for the SRD;
- System Attribute and Success Criteria Report
  - Mission Success Criteria;
  - QFD Matrices Documenting the Traceability from Campaign Objectives to Critical System Functions and Attributes;
  - Top-Level Measures of Effectiveness;
- Sensitivity Analyses Report;
  - Sensitivity Analysis Matrix;
  - Key System Attributes and Weightings; and
- CPBR Documentation which will include the CPBR Briefing Package, Action Items and Results.

## 2.7 STEP 4 - ESTABLISH THE FUNCTIONAL AND ALLOCATED SURFACE NAVY TAD BASELINES

The purpose of this step in the process is to establish the Surface Navy TAD functional baseline (performance, functional, physical) and allocate this baseline to existing and proposed nomenclatured subsystems for the Surface Navy TAD System circa 2015. This step will also define the migration plan to achieve this Allocated Baseline. See Figure 2-17 for a pictorial of the processes to be executed in this step of the system requirements engineering process.

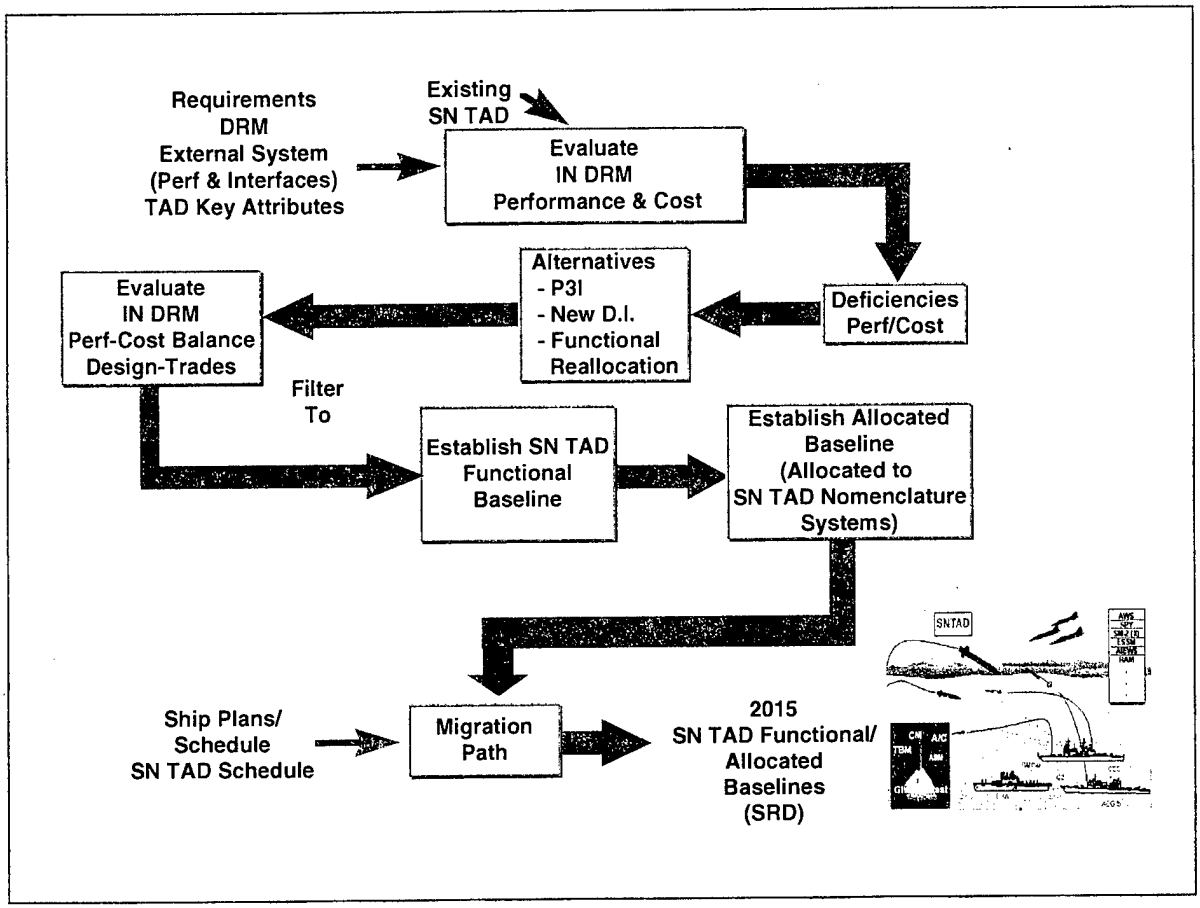



Figure 2-17. Establish the Baseline

In the performance of this step an analysis will first be conducted to determine capabilities and deficiencies of existing nomenclatured systems against the design reference mission. Potential contributions of candidate improvements and new development alternatives will then be considered. Surface Navy TAD functional requirements will be allocated between existing systems, improvements, and new development items to construct candidate baselines for the 2015 Surface Navy TAD System. A combination of analytical and engineering assessments will then be conducted to provide the basis for choosing a balanced solution (performance - cost - risk - schedule) and establishing an appropriate path for migration from the existing systems to the 2015 baseline. This migration path will be updated annually after initial execution of this systems engineering plan. Mission and product program SEMPs should then be modified to reflect this annual update.

Figure 2-18 provides an overview of the system requirements engineering processes to be conducted in this step in a functional flow format. This step establishes the physical architecture of the future Surface Navy TAD System. This step in the system requirements engineering process will identify the functions, key technical parameters and other attributes to be allocated to each nomenclatured subsystem of Surface Navy TAD. This step defines the interfaces between those subsystems and between those subsystems and systems external to Surface Navy TAD as well as the overall integration strategy and interoperability protocols and standards.

This step will answer the following key questions:

- What is the effectiveness and performance of the current and near term Surface Navy TAD and its subsystems? Does it meet the Conceptual Performance Baseline, Top-level Measure of Effectiveness, and Mission Success Criteria defined in Step 3?
- What are the system/subsystem alternatives?
- What is the integration strategy for these alternatives?
- What is the cost, risk, effectiveness and performance of the alternatives under consideration? Do they meet the conceptual performance baseline, top-level measures of effectiveness and mission success criteria defined in Step 3?
- Which of the alternatives provides the best balance between cost, risk and effectiveness at the total Surface Navy TAD System level?
- What is the migration path? Are there interim steps?
- What is the recommended allocation of functions, performance, effectiveness, cost, and other attributes to the Surface Navy TAD subsystem?

This step work group will be co-led by NSWCDD and JHU/APL with support from Surface Navy TAD element system engineers.

### 2.7.1 Step 4 Inputs

As depicted in Figure 2-18, the major inputs to Step 4 are as follows:

- The Conceptual Performance Baseline - developed in Step 3;
- DRM - from Step 1;
- Current System Interface Characteristics;
- Sensitivity Analyses Report including system attribute weightings - developed in Step 3;
- The Composite Functional Descriptions and Functional Flow Diagrams - initially developed in Step 2 and updated after Step 3;
- State-of-the-Art Technology;
- Mission Success Criteria - from Step 3;
- Top-level Measures of Effectiveness from Step 3;
- COEA/AOA Scenarios and Results; and
- Existing Test Data.

### 2.7.2 Evaluation Approach

The basic evaluation approach to be used for this step is to:

1. Assess/validate how well each current and alternative subsystem meets the individual functional and performance requirements and other attributes in the recommended

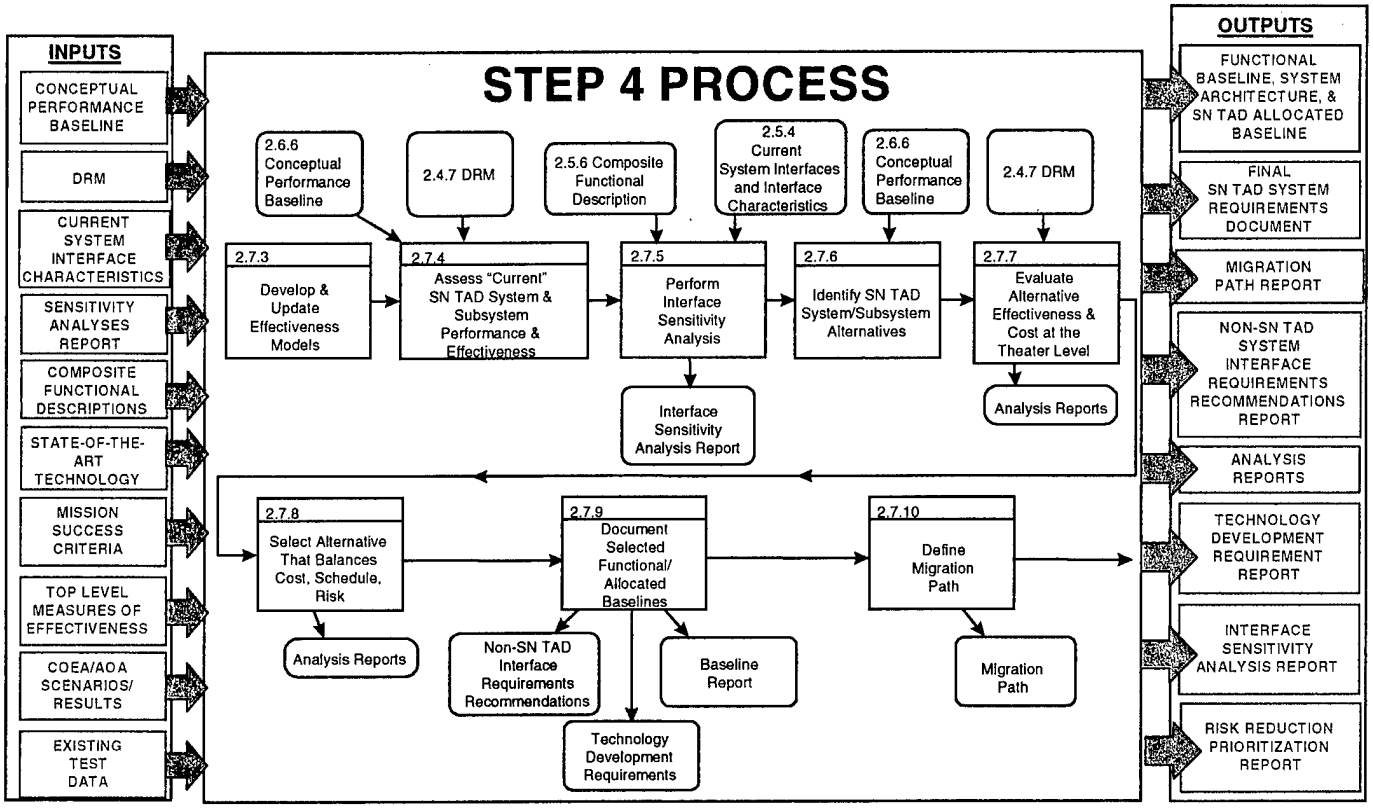



Figure 2-18. Baseline Establishment Process

Conceptual Performance Baseline that is developed in Step 3. This assessment will be done using individual simulations, test data for existing subsystems or other engineering analysis techniques as required. Identification of the engineering models will be made from the existing Surface Navy TAD technical community M&S tool set after Step 3 has defined the Conceptual Performance Baseline. No significant modifications to the M&S tools currently available are anticipated for this system requirements engineering effort.

2. Assess the performance and overall system effectiveness of current and alternative Surface Navy TAD Systems against each of the top-level measures of effectiveness defined in Step 3 using a force-on-force model (i.e., EADTB).

3. Assess the contribution of each of the current and alternative Surface Navy TAD component subsystems to the overall Surface Navy TAD effectiveness level achieved.

4. Evaluate the ability of the current and alternative Surface Navy TAD Systems to meet the Mission Success Criteria developed in Step 3.

5. Develop effectiveness versus cost comparisons as part of the process of reaching a preferred system concept that balances cost, schedule and risk with performance. The DRM developed in Step 1 will provide the input operational situations for these evaluations.

In refining the modeling and simulation strategy for this step of the system requirements engineering process during the execution of this plan, the following questions will be addressed for both performance and cost modeling:

- Is modeling and simulation the most effective method to get answers?
- What exact questions do we expect to answer using M&S?
- What models and simulations are best suited to answer these questions within cost/schedule bounds?
- What are the limitations of the models being used?
- Are there modifications required? What are the modification costs?
- Are the answers a critical path to the system requirements engineering process? What is the backup plan if the model does not or can not get the answers?
- What are the associated risks in using the selected model? Are they acceptable?

### 2.7.3 Develop and Update Effectiveness Models

The force on force models from Step 3 will form the basis of the effectiveness evaluations to be done in this step. These models will be evaluated to ensure they have sufficient fidelity to represent the functionality and performance characteristics of current and alternative subsystems to be evaluated in this task. Where these models do not adequately support the effectiveness evaluations to be performed in this step other current force on force models will evaluated for use. Where force on force models do not adequately represent these requirements, the models will be modified or lower level models will be used to provide input to the higher level models.

2.7.4 Assess Current Surface Navy TAD System and Subsystems

2.7.4.1 Assess the Performance of the Current Surface Navy TAD and Its Subsystems and Determine Its Effectiveness

The objective of this section is to assess the performance of the current Surface Navy TAD System against the required 2015 performance baseline developed in Step 3 and to determine how well the current Surface Navy TAD System and subsystems meet the performance, effectiveness, and mission success criteria defined in the previous steps in the context of the Design Reference Mission. Each subsystem will be assessed to determine its contribution to the top-level measures of effectiveness and mission success criteria defined in Step 3. Performance and functional shortfalls against the Conceptual Performance Baseline defined in Step 3 will be identified and used in the development of alternative concepts. Top-level effectiveness will be determined at both the overall Surface Navy TAD and the individual subsystem level. The top-level measures of effectiveness will include $P_K$, defended volume, and availability. In addition, the current Surface Navy TAD baseline will be validated against the operational requirements identified in Step 0 to ensure that all operational requirements are being adequately supported.

The simulations and models identified and developed in Section 2.7.3 will be the basis for the evaluation of current Surface Navy TAD System and subsystem effectiveness. Surface Navy TAD and subsystem effectiveness will be evaluated for each of the operational situations called out in the DRM. The results from each operational situation will be weighted and combined to produce a quantitative determination of how well the current Surface Navy TAD System meets the top-level MOEs. The weighting to be used in this step will be provided by Step 3.

2.7.4.2 Identify Causes of Performance and Functional Shortfalls of Current Surface Navy TAD and Its Subsystems

Where performance and functional shortfalls are identified analysis will be conducted to assess the cause of those shortfalls. These shortfalls will be identified according to the following categories:

- New required functionality;
- Increased performance required to meet performance shortfalls against the evolving threat in the littoral environment;
- Subsystem performance shortfalls against current performance requirements;
- Shortfalls caused by performance inadequacies of interfacing systems; and
- Shortfalls caused by compatibility and interoperability issues.

Areas where new subsystem development or technology development may be needed to meet performance and functional shortfalls will be identified.

2.7.4.3 Perform Life Cycle Cost Analysis of Current Surface Navy TAD and Its Subsystems

Detailed total life cost analysis will be performed on the subsystems that compose the current and near term Surface Navy TAD System. Cost analysis will be performed by a Work Group that includes the pertinent element systems engineers, logisticians, Navy cost analysts and core Surface Navy TAD personnel. Cost analyses performed in this step will incorporate the concepts of cost as an independent variable (CAIV). Specific ground rules that shall apply to the cost analysis are as follows:

- Costs to be included;
  - RDT&E for ongoing and near term improvements and enhancements

- SCN costs for future installations
- Other procurement costs, (i.e. OPN, WPN) for planned future installations and upgrades
- Projected O&S costs through the year 2015
- Projected 20 year O&S costs beginning in the year 2015
- Installation costs not in SCN and RDT&E budgets
- Impact on ship cost

- All costs shall be given in FY 98 dollars;
- Inflation indices and outlay profiles shall be identified at time of plan execution; and
- For subsystems that have significant non-Surface Navy TAD functionality, the costs shall be prorated between Surface Navy TAD and other virtual high level systems.

This effort will also identify the development, production and operations and support cost drivers and issues for the current subsystems for input in the development of alternative Surface Navy TAD concepts. An assessment of the adequacy of current budget lines to support planned upgrades, acquisitions and support will be made and shortfalls identified. Areas for possible cost savings will be noted and used in the development of alternative Surface Navy TAD system baselines for the 2015 time frame.

2.7.5 Perform Interface Sensitivity Analysis

An analysis will be performed to determine Surface Navy TAD effectiveness sensitivity to changes in internal and external interface accuracy, timeliness, data rates and external system performance. This analysis will provide insight into the definition of possible alternatives that would provide increases in Surface Navy TAD effectiveness.

2.7.5.1 Perform External Interface Sensitivity Analysis

Analysis will be performed on external systems that interface to Surface Navy TAD to determine Surface Navy TAD effectiveness sensitivity to the rate, accuracy and timeliness of data provided by those systems.

2.7.5.2 Perform Internal Interface Sensitivity Analysis

Analysis will be performed to determine sensitivity of Surface Navy TAD effectiveness to changes in internal interface data timeliness, accuracy and rates.

2.7.6 Identify Surface Navy TAD System and Subsystem Alternatives

This section identifies system alternatives to be considered for the Surface Navy TAD System. To bound the scope of the quantitative performance, effectiveness, and cost analysis that will be performed, the development and assessment of alternatives will be done in two steps. The first phase will develop a set of potential alternatives with no specific limit on how many alternatives will be considered. This first set will be assessed qualitatively to narrow the number of alternatives for detailed analysis using computer based modeling and simulation and detailed cost, risk and schedule analysis. At a minimum three alternatives (with excursions) will be recommended for more detailed analysis. These alternatives will address a range of cost and performance.

2.7.6.1 Propose Surface Navy TAD System Alternatives

The alternatives to be developed will encompass the full functionality of the composite Surface Navy TAD functional description defined previously in Step 2 and will include the

planned new Surface Navy TAD subsystem initiatives addressed in Section 2.5.5. These alternatives will also address previous and ongoing COEA/AOA recommendations.

These alternatives to be developed will address:

- Functions not currently performed by current systems but required to conduct Surface Navy TAD;
- Performance enhancements, new developments and innovations required to reach the desired level of performance and effectiveness;
- Possible elimination of current systems that were not shown to contribute to the overall Surface Navy TAD effectiveness in the analysis of the current Surface Navy TAD system;
- Reallocation of functions between current subsystems of Surface Navy TAD that would result in increased performance or reduced lifecycle cost;
- Internal and external interface requirements;
- Recommended modifications to external systems and interfaces;
- Duplication and overlap of functions by current subsystems;
- Compatibility and interoperability between subsystems; and
- System integration strategies to maximize system performance yet allow for independent development of subsystems.

The development of alternatives will address full compliance with the Conceptual Performance Baseline developed in Step 3. But, where achieving a desired level of performance is considered a potential cost driver, options will be developed for latter cost effectiveness analysis. Alternatives will include performance improvements and increased functionality of interfacing systems where increases in Surface Navy TAD effectiveness would result.

In developing alternatives the feasibility of upgrading existing subsystems to accomplish any increased functionality or to increase performance to the desired levels will be considered. The alternatives will be defined in terms of the functional and performance allocation to the individual Surface Navy TAD subsystems. Some of the functional allocation considerations to be used in developing alternatives will include:

- Capturing existing infrastructure when it is not a cost driver and does not constrain performance;
- Maximizing multifunction utilization of same equipment and software for both Surface Navy TAD and non-Surface Navy TAD functions;
- Keeping closely related and interdependent Surface Navy TAD functions in same subsystem;
- Keeping closely related Surface Navy TAD and non-Surface Navy TAD functions in same subsystem;
- Interfaces to non-Surface Navy TAD systems;
- Minimizing functional interaction across subsystem interfaces;
- Sensitivity to changes in external and internal interfaces;
- Facilitating development of subsystems by separate organizations;
- Training and skills of operators associated with individual subsystems;

- Domain expertise in the technology involved with developing the algorithms, software or equipment required to implement the function;
- Minimizing redundant developments;
- Throughput rate and timeliness requirements supported by infrastructure;
- Facilitating testing at subsystem and system levels;
- Requirements are verifiable across interfaces;
- Functions allocated to a given subsystem form logical sets;
- Subsystem utilization in multiple ship classes and combat systems; and
- Risk.

Candidate strategies for the integration of current and proposed Surface Navy TAD subsystems to form the Surface Navy TAD system of systems will be included in the alternatives to be developed. When deemed appropriate, second tier alternative concepts will be identified and carried forward to the next stage at which point cost versus effectiveness tradeoffs can be made. Examples of where a second tier option might be appropriate is the case in which two current Surface Navy TAD subsystems have significant functional overlap, but are difficult to decouple from interfacing subsystems without causing significant ripple. In such a case final second tier recommendations cannot be made until the detailed life cycle cost analysis is performed.

2.7.6.2 Select Alternatives for Detailed Cost and Effectiveness Analysis

Each proposed alternative will be:

- Validated against the operational requirements identified in Step 0;
- Validated against the updated functional requirements of Step 2;
- Validated against the performance baseline of Step 3. Options that have less than full performance but may result in a cost effective solution will be noted and carried forward for detailed cost effectiveness analysis;
- Assessed against the top-level measures of effectiveness including availability;
- Assessed as to ability to meet the mission critical requirements defined in Step 3;
- Assessed to determine system and subsystem sensitivity to (1) changes in integration architecture, interfacing systems and subsystems; (2) interface infrastructure capacities, accuracy and latencies and (3) changes in threat;
- Assessed for inter-element compatibility and interoperability;
- Investigated to determine if current or near term technology supports the proposed subsystem concepts. Technology requirements will be compared to currently planned technology and functional roadmaps. Alternatives in which new technology investments would result in significant performance, cost, or functional payoffs will be identified and carried forward as high risk options;
- Assessed as to cost and schedule risk;
- Assessed to determine if current RDT&E budgets support the alternative; and
- Assessed for training implications.

The above assessments and investigations will be engineering studies that will not require the use of force-on-force models and simulations that will be used in Section 2.7.7.

The systems engineering tool used to develop the functional descriptions of the current Surface Navy TAD System in Step 2 will be used to facilitate the validation of the proposed alternatives and ensure functional completeness and traceability to requirements. This evaluation phase will not require the use of a force on force simulation model but will utilize engineering analysis, individual subsystem models and qualitative assessments to narrow the scope of alternatives to be rigorously analyzed in the final selection process.

Three or more alternatives (with 2nd tier options) will be recommended for detailed performance, effectiveness, and cost analysis. These alternatives will represent a breadth of risk, cost and performance.

2.7.6.3 Develop System Verification Requirements for Selected Alternatives

System verification requirements for each new or modified Surface Navy TAD subsystem identified in the alternatives selected for detailed analysis will be developed. These verification requirements should be at sufficient detail to support RDT&E cost estimates and to identify test assets and facilities that will be identified in the migration plan.

2.7.7 Evaluate Alternatives Effectiveness and Cost at the Theater Level

2.7.7.1 Assess the Effectiveness and Performance of the Proposed Surface Navy TAD Alternatives

The object of this section is to quantitatively assess the performance and effectiveness of the alternative Surface Navy TAD Systems and subsystems selected for further detailed analysis. These alternatives will be evaluated against the performance baseline developed in Step 3 and evaluated to determine how effectively these alternatives perform in the context of the Design Reference Mission defined in the previous steps. The analysis to be performed in this section is similar to that described for the current Surface Navy TAD System and its subsystems described in Section 2.7.4. Each alternative will be assessed to determine it's capability in terms of the overall top-level Surface Navy TAD measures of effectiveness defined in Step 3. Each subsystem in the alternative will be evaluated for its ability to support the performance requirements allocated to that element.

The simulation models used in evaluating the current Surface Navy TAD System will be the basis for the evaluation of alternative Surface Navy TAD System and subsystem effectiveness. Surface Navy TAD and subsystem performance and effectiveness will be evaluated for each of the operational situations called out in the DRM. The results from each operational situation will be weighted and combined to produce a quantitative determination of how well each alternative meets the top-level measures of effectiveness. The contribution of each subsystem to these measures of effectiveness will also be determined.

2.7.7.2 Perform Cost Analysis of Alternatives

Life cycle cost analysis will be conducted on each alternative to enable cost/effectiveness comparisons. The analysis will be similar to that performed for the current Surface Navy TAD System baseline described in Section 2.7.4.3 and will be based on the principles of cost as an independent variable. The development costs for proposed new systems and modifying existing systems will include the cost of performing system verification. Key cost drivers for all Surface Navy TAD subsystems will be identified and used for possible revisions to the alternatives to be considered. Cost risks will be identified. Cost comparisons will be done at the Surface Navy TAD System of systems level. In keeping with CAIV principles, cost comparisons will include operational support and production costs as well as development costs. Areas where investments during development would reduce production and operational support costs will be identified. Cost drivers and associated metrics will be identified.

2.7.7.3 Assess Risks Associated with Each of the Alternatives

Each alternative will be assessed for technical, cost and schedule risk. Specific risk areas will be identified and risk monitoring and recommendations for risk management procedures for use in later development phases will be made.

2.7.7.4 Analyze Interface Sensitivity of Each Alternative

This section will build on the interface analysis done in Step 2. Internal and external interface performance requirements that stress or significantly impact system performance such as data link reporting latency will be identified and documented. The accuracy and timeliness performance of external system interfaces will be analyzed for impact on overall Surface Navy TAD effectiveness and performance. For each of the alternatives, an analysis will be conducted to identify situations where a function in one subsystem is closely coupled to a function in another subsystem and that function is sensitive to changes in the interface or implementation of the interfacing function. Analysis will be conducted to determine if the integration strategy, standards and protocols support the subsystem functional interfaces in the alternatives under consideration in a cost effective manner with reasonable technical risk. These analyses may trigger an adjustment to the alternatives under consideration.

2.7.8 Select an Alternative that Balances Performance, Cost, Schedule and Risk

The overall objective of the Surface Navy TAD system requirements engineering process is to define a baseline for FY 2015 that balances cost, effectiveness and risk. This baseline must be affordable, within the scope of current budget projections and programmatically achievable within the time constraints. The cost effectiveness comparisons will be done for: (1) life cycle cost assessed from present through FY 2015 and (2) a 20-year life cycle beginning in FY 2015. The following features of each alternative will be ranked and compared against the total Surface Navy TAD life cycle costs:

- Top-level measures of effectiveness
  - $P_k$
  - Defended Volume
  - Availability
  - etc.;
- Performance against mission success criteria;
- Support of individual subsystem and higher level ORDs;
- Support of Conceptual Performance Baseline of Step 3;
- Risk
  - Overall development risk assessment
  - Ability of subsystems to achieve allocated performance requirements
  - Schedule
  - Availability of required technology;
- Time to earliest feasible IOC for the nomenclatured systems comprising the alternative; and
- Sensitivity to changes in other subsystems.

These cost effectiveness comparisons will be performed for the FY 2015 baseline. In addition, the cost of each alternative will be compared to the currently projected Surface Navy TAD budget line. A Work Group comprised of NSWCDD, JHU/APL and effected program managers and systems engineers will be utilized in this effort.

2.7.9 Document Selected Functional and Allocated Baselines

The recommended alternative will be documented in a Baseline Report that contains the following:

- Allocation of functions, performance requirements, and other attributes to subsystems, (e.g., nomenclatured subsystems);
- Surface Navy TAD system functional architecture and tiered functional flow diagrams;
- External and internal system and subsystem interface descriptions;
- Traceability of performance and functional requirements to:
  - The Conceptual Performance Baseline
  - Top-level measures of effectiveness
  - Operational requirements
  - Mission success criteria
  - Mission area;
- Integration strategy; and
- Required interface and interoperability standards.

This Baseline Report documents the Allocated Baseline for each Surface Navy TAD subsystem and together with the performance baseline of Step 3 will form the basis of the Surface Navy TAD System Requirements Document. The SRD will define functional, interface, performance and verification requirements at the mission, at the mission program and at the individual subsystem levels.

In addition, a Technology Development Requirements Report, a Risk Reduction Prioritization Report and a Non-Surface Navy TAD Systems Interface Requirements Report will be written. The Technology Development Requirements Report will detail the required technology efforts needed to support the evolution to the FY 2015 capability along with estimates of required funding and schedules for these efforts. The Risk Reduction Prioritization Report will recommend risk reduction efforts that should be performed in support of the development of the recommended Surface Navy TAD baseline. The non-Surface Navy TAD systems interface requirements recommendations will document improvements that are required in systems external to Surface Navy TAD to support the recommended Surface Navy TAD alternative. It will also document those improvements that are not essential to the selected alternative, but provide cost effective enhancements to overall Surface Navy TAD performance and effectiveness.

2.7.10 Define Migration Path

- A plan of action required to reach the Surface Navy TAD FY 2015 baseline will be delivered. This plan of action will include the following:
- Termination and phase out plans for current subsystems not included in the FY 2015 baseline;

- Phased development plan that evolves the current Surface Navy TAD System to the FY 2015 baseline;
- Top-level schedules and budget estimates for each required improvement and new subsystem development;
- Assessment of current RDT&E budgets to support the evolution to the FY 2015 baseline;
- Top-level ship integration plan including effects of signature and emission on total platform design;
- Interim subsystem improvements and near term developments;
- Recommendations for post interim configurations; and
- POM inputs to implement the migration path.

2.7.11 Step 4 Products

The following products will be produced by this task:

- FY 2015 baseline Report (Functional Baseline, System Architecture, and Surface Navy TAD Allocated Baseline);
- Final Surface Navy TAD System Requirements Document;
- Migration Path Report;
- Non-Surface Navy TAD Systems Interface Requirements Recommendations Report;
- Analysis Reports;
- Technology Development Requirements Report;
- Interface Sensitivity Analysis Report; and a
- Risk Reduction Prioritization Report.

## 2.8 STEP 5 - CONDUCT TAD SYSTEM REQUIREMENTS REVIEW (TSRR)

The Surface Navy TAD system requirements engineering process culminates with the TAD System Requirements Review (TSRR) during which the Surface Navy TAD baseline, migration path, non-Surface Navy TAD requirements recommendations, technology development requirements and supporting analysis reports are presented to the Navy's senior leadership for concurrence, transition to program managers for execution, and POM planning input.

The purpose of this step is to obtain approval of the Surface Navy TAD baseline. The TSRR presents the objectives and the allocation of these requirements to both systems/subsystems and external interfaces. The intent of this review is to obtain approval of the recommended Surface Navy TAD baseline and the proposed migration path from existing systems to the composite 2015 baseline. Recommended adjustments to both new and existing developments are provided for redirection of the present design processes and POM planning input. The results of this process will be updated and reviewed on an annual basis to incorporate lessons learned, evolving technology and new requirements.

The process for conducting the TSRR follows the same system requirements engineering model used throughout this plan in which inputs are identified and processes are designed to achieve a desired output. Figure 2-19 shows this process and the composition of each of its components. Each of these components for executing the TAD System Requirements Review are discussed in the following subsections.

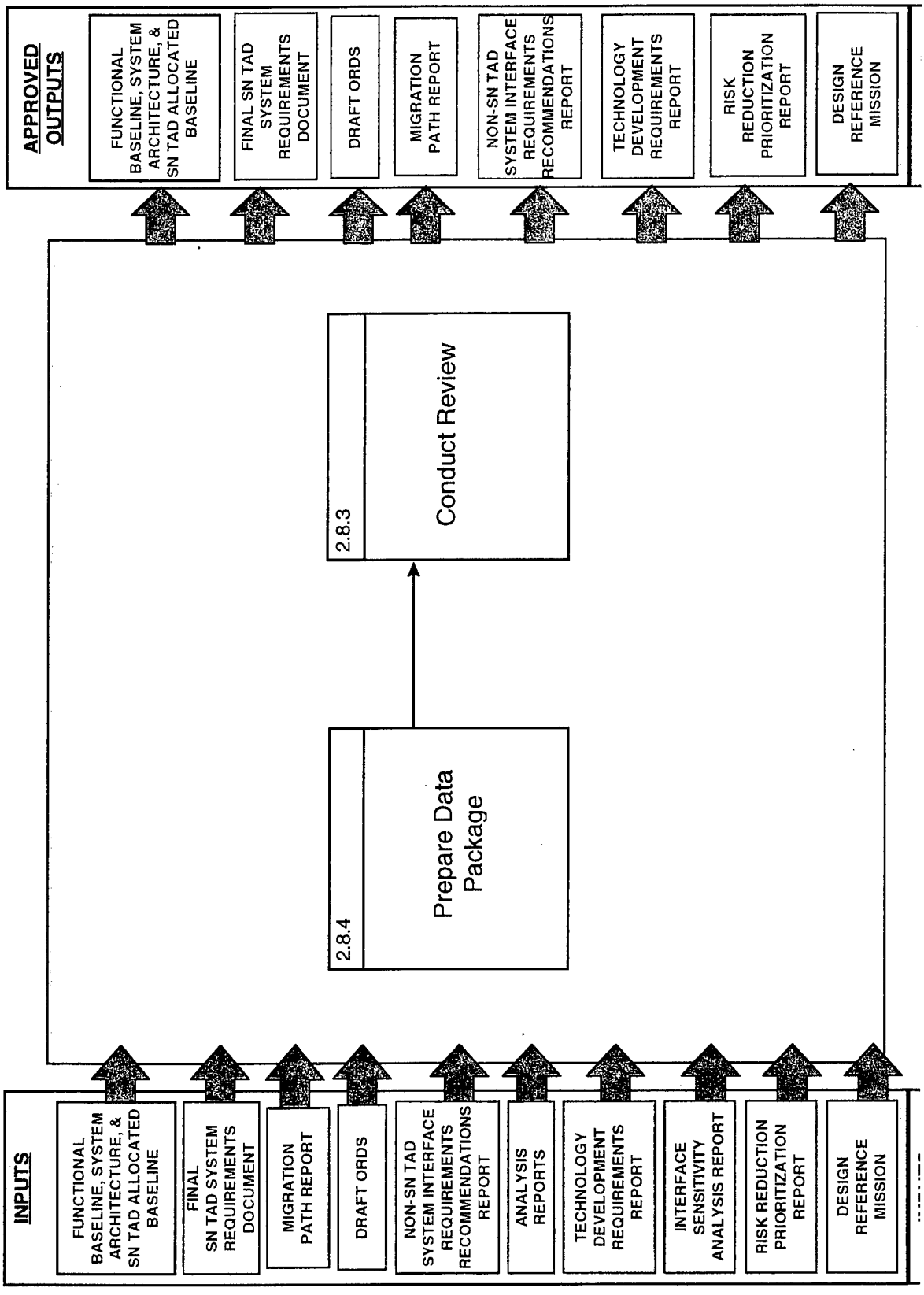



Figure 2-19. TSRR Execution Process

2.8.1 TSRR Objectives

As stated above, the TSRR provides a forum for presenting the results of the Surface Navy TAD system requirements engineering process to the Navy's senior uniformed and civilian leadership for concurrence and approval of the Surface Navy TAD baseline, POM planning input and approval for transition to the respective program managers for execution. These objectives, an approved Surface Navy TAD System Requirements Document (SRD) and concurrence on non-Surface Navy TAD requirements recommendations are the desired outputs of the TSRR.

2.8.2 Participants

The TAD System Engineer shall chair the TSRR with support from JHU/APL and NSWCDD with participants as identified in Table 1-1.

2.8.3 Material to be Presented

The material to be presented represents the products of the Surface Navy TAD System requirements engineering process. The material to be presented will be the supporting Surface Navy TAD System requirements products and findings and will include::

- The recommended Surface Navy TAD baseline requirements;
- The recommended Surface Navy TAD SRD;
- A recommendation for the non-Surface Navy TAD requirements;
- The migration paths to achieve the Surface Navy TAD baseline;
- Draft ORDs;
- Technology development requirements including recommendations for R&D, Advanced Technology Demonstrations and Advanced Concept and Technology Demonstrations;
- Analysis reports;
- Interface Sensitivity Analysis Report; and
- Risk Reduction Prioritization Report.

2.8.4 Step 5 Inputs

The Step 5 inputs defined in Section 2.8.3 are shown in Figure 2-19.

2.8.5 Data Package

The supporting products and findings which substantiate the recommended Surface Navy TAD system design will be compiled into a data package for presentation and reference at the TSRR. The data package will consist of the following the products:

- Surface Navy TAD Level System Requirements Document (includes: top-level performance, functional and performance allocations for each Surface Navy TAD subsystem including the key functional interface requirements and Surface Navy TAD functional architecture);
- Functional flow diagrams;
- Functional descriptions at Surface Navy TAD and subsystem levels;
- Analysis and simulation data;
- Trade studies;

- Draft ORDs;
- Recommended interface standards;
- Recommended interoperability standards;
- Non-Surface Navy TAD System Interface Requirement Report;
- Risk Reduction Prioritization Report; and a
- Design Reference Mission.

2.8.6 Step 5 Products

The products of Step 5 are the approved outputs of this system requirements engineering effort. The draft ORDs will be passed to CNO for consideration. The other products will be passed to cognizant program managers for execution. After completion of the TSRR, annual updates will be conducted to incorporate lessons learned and new requirements and to provide training opportunities for systems engineers.

# SECTION 3
## WORK BREAKDOWN STRUCTURE

This section provides the Work Breakdown Structure (WBS) for executing the Surface Navy TAD system requirements engineering activities.

## 3.1 WORK BREAKDOWN STRUCTURE

The Work Breakdown Structure for executing the Surface Navy TAD system requirements engineering activities is provided in Figure 3-1

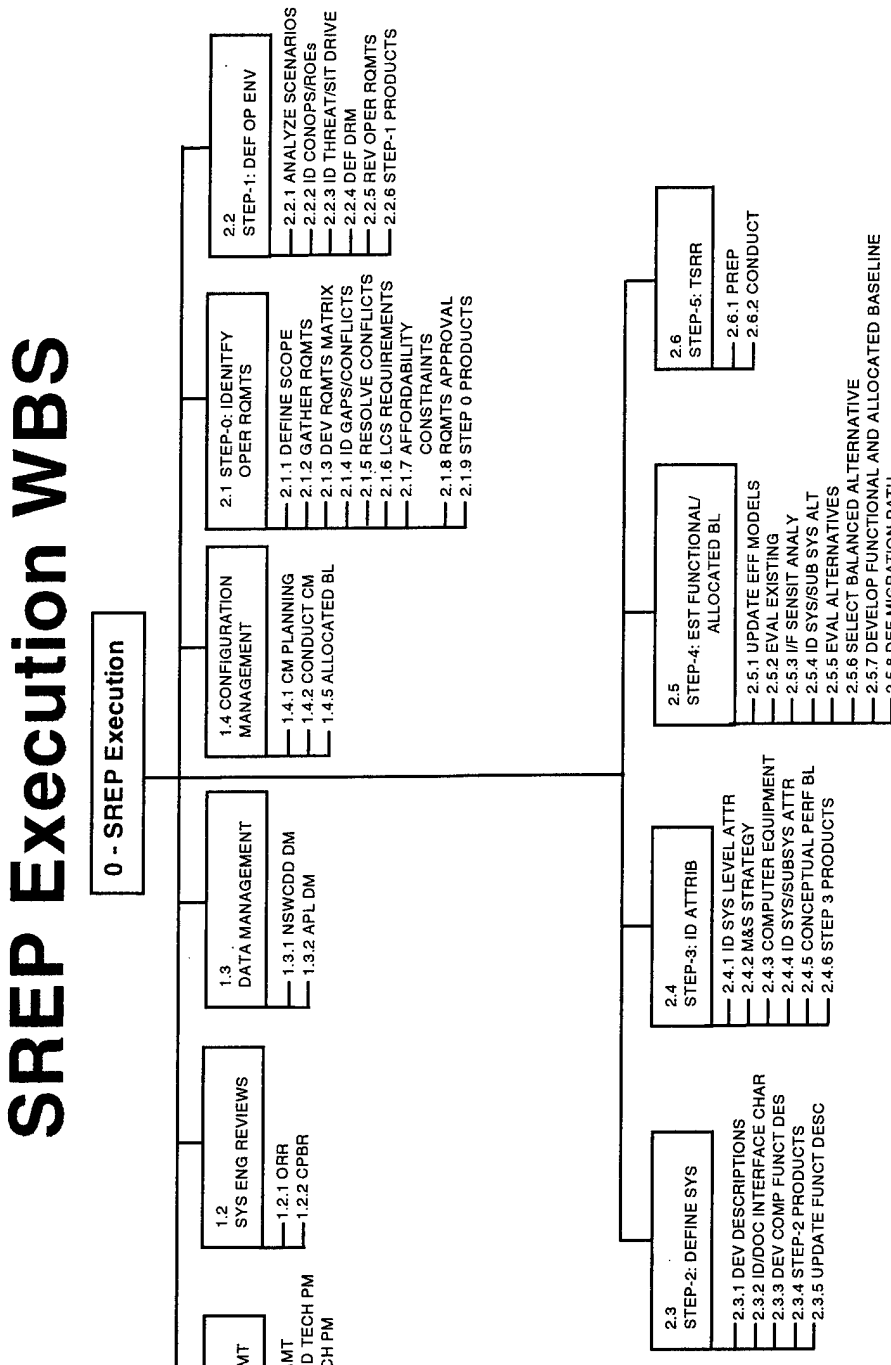



Figure 3-1. Surface Navy TAD SEP Work Breakdown Structure

# SECTION 4
# GLOSSARY

## 4.0 SURFACE NAVY TAD SYSTEM REQUIREMENTS ENGINEERING GLOSSARY

This glossary provides definitions of essential terms as used in the TAD System Requirements Engineering Plan. This glossary is an integral part of the TAD SEP and is to be used in the development of documentation called for in this document.

### 4.1 Definitions

**ALLOCATED BASELINE:** The approved documentation describing the Surface Navy TAD "System of System" sub-systems, (i.e. the nomenclatured system's functional, performance, interoperability, and interface requirements that are allocated from those of the higher level system), Surface Navy TAD. The Allocated Baseline will include the interface requirements with interfacing sub-systems; design constraints, derived requirements (functional and performance); and verification requirements and methods to demonstrate the achievement of those requirements and constraints. The Surface Navy TAD Allocated Baseline will be in the form of a System Requirements Document (SRD) for the Surface Navy TAD nomenclatured subsystems and will be the primary product of Step 4 of this plan. The SRDs will be the basis for the Program Manager's implementation of the nomenclatured systems.

**ATTRIBUTE:** Surface Navy TAD system characteristics which can be organized into various categories such as functions, constraints, performance parameters, cost, physical characteristics, supportability and availability.

**COMPOSITE FUNCTIONAL DESCRIPTION:** Hierarchical description of the functions to be performed by the future Surface Navy TAD system of systems required to meet the full set of Surface Navy TAD operational requirements. This functional model is developed from the functionality of current Surface Navy TAD systems and a functional decomposition of Surface Navy TAD related operational requirements.

**CONCEPTUAL PERFORMANCE BASELINE (CPB):** The documentation that identifies the Surface Navy TAD "System of Systems" performance concept chosen to meet the needs identified in the top level operational requirements documents. The Conceptual Performance Baseline includes broad objectives and thresholds for key cost, schedule and performance parameters, including supportability. Objectives will include thresholds identifying minimum acceptable requirements. The initial CPB will be the primary product of Step 3 of the system requirements engineering process described in this plan. Reevaluation of alternative concepts or approaches will be performed if Step 4 of this plan determines that key parameters are not met.

**CONCEPT OF OPERATIONS (CONOPS):** A document that addresses the operational employment of a system(s).

**DESIGN REFERENCE MISSION (DRM):** A systems engineering approach which details the operational environment within which the Surface Navy TAD system attributes

and requirement allocations are evaluated and used to evaluate the relative merit of proposed system concepts and upgrades for the TAD mission area. It defines the total envelope of the operational environments in which the Surface Navy TAD system must perform from the early stages of initial presence to the end of hostilities. The DRM is one of the key products.

**FUNCTIONAL BASELINE:** The approved documentation describing the Surface Navy TAD "System of System's" functional, performance, interoperability, interface requirements, and the verification required to demonstrate the achievement of those specified requirements. The basis for the Functional Baseline is the CPB defined in Step 3. The Functional Baseline is finalized in Step 4 of this plan.

**INTEGRATED PRODUCT TEAM:** Team composed of representatives from all appropriate functional disciplines working together with a Team Leader to build successful and balanced programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision-making.

**LIFE CYCLE COST ANALYSIS:** The identification, quantification, and qualification of LCC by segment with the purpose of establishing the cost interrelationships and the effect of each contributor to the total LCC.

**LIFE-CYCLE COST (LCC):** The sum total of the direct, indirect, non-recurring, and other related costs incurred, or estimated to be incurred, in the design, development, production (including manufacture and fabrication), acquisition, test and evaluation, acceptance, operation, maintenance, modernization, deactivation, and support of a configuration item over its anticipated life span.

**MEASURE OF EFFECTIVENESS (MOE):** Metric used to quantify a systems ability to meet its operational objectives. Examples of top level MOEs include probability of killing or countering a threat, system availability, defended area etc. Top Level MOEs may be decomposed into supporting MOEs. MOEs are typically evaluated for a specific or a series of operational situations or scenarios. MOEs are used to derive lower level technical performance requirements that are allocated to specific functions and subsystems.

**MIGRATION PATH:** A plan of actions and milestones required to reach the Surface Navy TAD FY 2015 baseline from the current Surface Navy TAD capability. The migration path is a major product of Step 4.

**MISSION SUCCESS CRITERIA:** Quantitative criteria to be used to assess if a ship, battle group, joint command, etc. will meet an assigned mission. The system being evaluated may be inherently involved in the mission or it may play only an enabling role. Examples might include such criteria as: (a) the battle group was able to successfully defend a specific area against ballistic missiles with a 99% probability of success, or (b) the task force was able to conduct sustained NGFS operations in the presence of hostile ASM engagements.

**OPERATIONAL REQUIREMENTS REVIEW:** The formal review of the results of Step 0 (Operational Needs and Requirements), Step 1 (Define the Operational Environment), and Step 2 (Define System Boundaries), of the Surface Navy TAD "System of Systems" engineering process.

**OPERATIONAL REQUIREMENTS TRACEABILITY MATRIX:** A matrix which traces operational requirements from the top level mission area down to the specific element/nomenclatured system. The matrix shows the decomposition and relationship of the operational requirements and is correlated with functional requirements.

**PERFORMANCE REQUIREMENT:** The extent to which a mission/operation or function must be executed, generally measured in terms of quantity, quality, coverage, timeliness, or readiness.

**QUALITY FUNCTIONAL DEPLOYMENT:** A structured process which provides an efficient and effective mechanism to decompose top-level system requirements into a prioritized set of lower level functional and design requirements.

**SURFACE NAVY THEATER AIR DEFENSE (SURFACE NAVY TAD) SYSTEM:** An integrated system which is comprised of all Surface Navy related Theater Air Defense resources and their interfaces with non-Surface Navy TAD and other Navy assets.

**SYSTEM OF SYSTEMS:** An integrated system comprised of a structural order of systems in which systems at any one level are embedded in successively higher level systems that address discrete operating tasks, mission areas, and ultimately joint operating forces. Specifically, Surface Navy TAD is comprised of all Surface Navy related Theater Air Defense resources and their interfaces with non-Surface Navy TAD and other Navy asset. This is a "system of systems" made up of various component systems. Similarly, the Surface Navy TAD "system of systems" is a subsystem of the broader Navy TAD, Joint TAD, and Theater Air Warfare "system of systems".

**SYSTEM REQUIREMENTS DOCUMENT:** A requirements document that translates operational requirements into functional, technical performance, interface, interoperability, and verification requirements and allocates those requirements to lower level subsystems. It defines the environment in which the system must operate as well as the threats the system must address.

**TAD SYSTEM REQUIREMENTS REVIEW (TSRR):** The final formal review and approval event conducted as Step 5 of the Surface Navy TAD System requirements engineering process.

# APPENDIX A:
# ACRONYMS

| | |
|---|---|
| AADC | Area Air Defense Commander |
| ACTD | Advance Concept and Technology Demonstration |
| AIEWS | Advanced Integrated Electronic Warfare System |
| ASM | Anti-Ship Missile |
| ASN RDA | Assistant Secretary of the Navy, Research, Development and Acquisition |
| ASR | Alternative Systems Review |
| AWS | AEGIS Weapon System |
| $BMC^4I$ | Battle Management Command, Control, Communications, Computers and Intelligence |
| BMDO | Ballistic Missile Defense Office |
| CAIV | Cost As An Independent Variable |
| CDR | Critical Design Review |
| CEC | Cooperative Engagement Capability |
| COEA/AOA | Cost and Operational Effectiveness Analysis |
| CONOPS | Concept of Operations |
| CNO N4 | OPNAV Deputy Chief of Naval Operations (Logistics) |
| CNO N6 | OPNAV Director, Space Information Warfare Command and Control |
| CNO N85 | OPNAV Director, Expeditionary Warfare Division |
| CNO N86 | OPNAV Surface Warfare Division |
| CNO N865 | OPNAV Director Theater Air Warfare |
| CNO N88 | OPNAV Air Warfare Division |
| CPB | Conceptual Performance Baseline |
| CPBR | Conceptual Performance Baseline Review |
| CSSE | Chief Ship Systems Engineer |
| CWSE | Chief Warfare Systems Engineer |
| DAB | Defense Acquisition Board |
| DARPA | Defense Advanced Research Project Agency |
| DASNC4I | Deputy Assistant Secretary of the Navy, Battle Management Command, Control, Communications, Computers and Intelligence |
| DIA | Defense Intelligence Agency |
| DPG | Defense Planning Guidance |
| DRM | Design Reference Mission |
| EADSIM | Extended Air Defense Simulation |
| EADTB | Extended Air Defense Test Bed |
| ESSM | Evolved Sea Sparrow Missile |
| EW | Electronic Warfare |
| FCA | Functional Configuration Audit |
| GCAM | Generalized Campaign Analysis Model |
| IPPD | Integrated Product/Process Development |
| IPT | Integrated Product Team |
| JHU/APL | Johns Hopkins University/Applied Physics Laboratory |

| | |
|---|---|
| JMCOMS | Joint Maritime Communications |
| JTAMDO | Joint Theater Air Missile Defense Office |
| LCC | Life Cycle Cost |
| M&S | Modeling and Simulation |
| MFR | Multi-Function Radar |
| MIT/LL | Massachusetts Institute of Technology/Lincoln Lab |
| MNS | Mission Needs Statement |
| NAVSEA | Naval Sea Systems Command |
| NAVSEA 03 | Deputy Commander For Engineering, Naval Sea Systems Command |
| NAVSEA 09 | Vice Commander, Naval Sea Systems Command |
| NAVSEA CHENG | Naval Sea Systems Command Chief Engineer |
| NAWC WPNS/CL | Naval Air Warfare Center, Weapons Division China Lake |
| NDC | Navy Doctrine Command |
| NGSDS | Next Generation Self Defense System |
| NRaD | Naval Command, Control and Ocean Surveillance Center (NCCOSC) Research, Development, Test and Evaluation Division |
| NRL | Navy Research Laboratory |
| NSWC | Naval Surface Warfare Center |
| NSWCDD | Naval Surface Warfare Center - Dahlgren Division |
| O&S | Operations and Support |
| OCMD | Overland Cruise Missile Defense |
| ONI | Office of Naval Intelligence |
| ONR | Office of Naval Research |
| OPN | Operations Procurement Navy |
| OPNAV | Office of Chief of Naval Operations (CNO) |
| OPSIT | Operational Situations |
| OPTEVFOR | Operational Test and Evaluation Force |
| ORD | Operational Requirements Document |
| ORR | Operational Requirements Review |
| PCA | Physical Configuration Audit |
| PDR | Preliminary Design Review |
| PEO | Program Executive Officer |
| PEO CLA | Program Executive Officer, Carriers, Littoral Warfare and Auxiliary Ships |
| PEO CU | Program Executive Officer, Cruise Missiles and Unmanned Aerial Vehicles |
| PEO SC | Program Executive Officer, Surface Combatants |
| PEO SCS | Program Executive Officer, Space, Communications and Sensors |
| PEO(TAD) | Program Executive Officer, Theater Air Defense |
| PEO(TAD)-SE | Program Executive Officer, Theater Air Defense Systems Engineering |
| PHS&T | Packaging, Handling, Storage & Transportation |
| PM | Program Manager |
| PMT | Program Management Team |
| POM | Program Objectives Memorandum |

| | |
|---|---|
| QFD | Quality Functional Deployment |
| RAM | Rolling Airframe Missile |
| RDT&E | Research, Development, Test and Evaluation |
| ROE | Rules of Engagement |
| RRA | Risk Reduction Activities |
| SBS | Senior Battle Staff |
| SCN | Shipbuilding and Construction Navy |
| SET | Systems Engineering Team |
| SE | Systems Engineering |
| SECDEF | Office of Secretary of Defense |
| SECNAV | Office of Secretary of the Navy |
| SEM | Systems Engineering Management |
| SEMP | Systems Engineering Management Plan |
| SEP | Systems Engineering Plan |
| SET | Systems Engineering Team |
| SFR | System Functional Review |
| SM | Standard Missile |
| SN TAD | Surface Navy Theater Air Defense |
| SPAWAR | Naval Space Warfare Command |
| SRD | System Requirements Document |
| SRR | System Requirements Review |
| SSDS | Ship Self Defense System |
| SSR | Specific System Representation (EADTB) |
| SSR | Software Specification Review |
| STAR | System Threat Assessment Report |
| TAD | Theater Air Defense |
| TAW | Theater Air Warfare |
| TBMD | Theater Ballistic Missile Defense |
| THAAD | Theater High Altitude Area Defense |
| TSRR | Theater Air Defense (TAD) System Requirements Review |
| USMC | United States Marine Corps |
| USW | Under Sea Warfare |
| VLS | Vertical Launching System |
| VSR | Volume Search Radar |
| WBS | Work Breakdown Structure |
| WPN | Weapons Procurement Navy |

# APPENDIX B:
# DELIVERABLES

## DELIVERABLES

The following list shows the deliverables required by this plan:

1. System Requirements Document (SRD) Deliverables

| | SRD | SN TAD SYSTEM ENGINEERING PROCESS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Step 0 | Step 1 | Step 2 | Step 3 | Step 4 | Step 5 |
| | Scope of the System | | | Initial Draft | | Final | SRD Approval |
| | Threats/Environment | Initial Draft | Prelim. | | | Final | |
| | Operational Requirements | Initial Draft | | | Prelim. | Final | |
| Functional Baseline | SN TAD Functional Requirements | | | Initial Draft | Prelim. | Final | |
| Functional Baseline | SN TAD Technical Performance/MOEs | | | | Prelim. | Final | |
| Functional Baseline | SN TAD Interface Requirements | | | Initial Draft | | Final | |
| Functional Baseline | SN TAD Verification Requirements | | | | Prelim. | Final | |
| Allocated Baseline | Allocated Functional/Performance | | | | | Final | |
| Allocated Baseline | Interface Requirements | | | | | Final | |
| Allocated Baseline | Allocated Verification Requirements | | | | | Final | |
| | Reviews | | ORR | | CPBR | TSRR | |

**2. STEP F** — **DUE AT:**

**2.F-1** Draft Operational Requirements Documents — Completion of Step

**2. F-2** Operational Requirements Report — Completion of Step

**3. STEP G** — **DUE AT:**

**3. G-1** Design Reference Mission — Completion of Step

**3. G-2** DRM Analysis Report — Completion of Step

**4. STEP H**

**4. H-1** Current Surface Navy TAD Hierarchical Functional — Completion of Step

DELIVERABLES
(Continued)

| | |
|---|---|
| **4. H-2** Composite Surface Navy TAD Functional Description | Completion of Step |
| **4. H-3** Functional Flow Diagrams For the Composite Surface Navy TAD System | Completion of Step |
| **5. STEP J** | **DUE AT:** |
| **5. J-1** Conceptual Performance Baseline | Completion of Step |
| **5. J-2** System Attribute and Success Criteria Report | Completion of Step |
| **5.J-3.** Sensitivity Analysis Report | Completion of Step |
| **6. STEP K** | **DUE AT:** |
| **6. K-1** FY 2015 baseline Report (Functional Baseline, System Architecture and Surface Navy TAD Allocated Baseline) | Completion of Step |
| **6. K-2** Migration Path Report | Completion of Step |
| **6. K-3** Non-Surface Navy TAD Systems Interface Requirements Recommendations Report | Completion of Step |
| **6. K-4** Technology Developments Requirements Report | Completion of Step |
| **6. K-5** Interface Sensitivity Analysis Report | Completion of Step |
| **6. K-6** Risk Reduction Prioritization Report | Completion of Step |

# APPENDIX C:

# COMPARISON OF THE TAD-SE COMMON REQUIREMENTS SYSTEM ENGINEERING PROCESS AND THE C4ISR ARCHITECTUREFRAMEWORK

The C4ISR Architecture Framework provides rules, guidance, and product descriptions for the development and presenting of C4ISR architectures to facilitate the understanding, comparing, and integration of architectures developed under separate efforts. Its goal is to enhance C4ISR interoperability. The framework describes three architectural views and recommended products. These three views are described in more detail at the end of this appendix. The C4ISR Architecture Framework and the Common Requirements System Engineering Process as provided in this document address similar needs, but the emphasis is somewhat different. The C4ISR Architecture Framework addresses the need for systems in a joint operational environment to share and exchange data in a standardized way. The architectural framework supports the goals of:

- Using standardized supporting products when needed or helpful
- Using common terms and definitions
- Describing joint and multi-national relationships in a standard way
- Describing interoperability requirements in a standard way

The thrust of the framework document is on how to describe C4ISR architectures from three points of view: operational, system and technical. The architectural descriptions called out for in the framework document emphasize interfaces, information exchange requirements, system functionality and common standards. The Common Requirements System Engineering Process describes a process for establishing system requirements from a naval system of systems perspective. Although it clearly addresses joint interfaces, the emphasis in the TAD-SE Common Requirements System Engineering Process is on determining required functionality and performance of naval systems versus detailed joint information exchange requirements.

Figure 1 of this appendix provides a summary of the two product sets. Products identified as essential in the C4ISR framework are shown in italics. Whereas the Common System Requirements Engineering Process begins with current Operational Requirements Documents (ORDs), the process proscribed by the architectural framework concept begins with the development of an operational architecture.

The Operational architecture step of the C4ISR is roughly viewed as an input to the ORD/DRM process. The thrust of this operational architecture is a description of the interfaces between notional operational nodes (clusters of operational elements). Optional operational architecture products include an activity model. At the more detailed level the activity model is similar to process descriptions used in process re-engineering as a tool for identifying process improvements and automation priorities. This is seen as a tool to be used later in the systems engineering process as an aid in identifying specific automation needs.

The system and technical architecture defined by the C4ISR framework corresponds to the functional baseline with its allocation to subsystems defined in the SRD and Baseline Report described previously in this document. Here the system functionality description corresponds to the hierarchical functional descriptions, composite functional descriptions and functional flow diagrams. The system performance parameters matrix corresponds to the conceptual performance baseline and the system interface descriptions are provided as part of Step 3 (Define System Boundaries). The technical architecture is seen as similar to the high level mandates (e.g. TADIL J, DII COE) and standards to be called out in the SRD.

Although there is similarity between the products of the *C4ISR Architecture Framework* and the Common Systems Engineering Process their products differ in emphasis and there is not a complete one for one match. However, it appears that the Common System Requirements Engineering Process supports the intent of the mandatory products called for in the framework document and several of the optional ones. Table 1 provides a mapping of Common System

Requirements Engineering Process products to those called for in the C4ISR Architecture Framework.

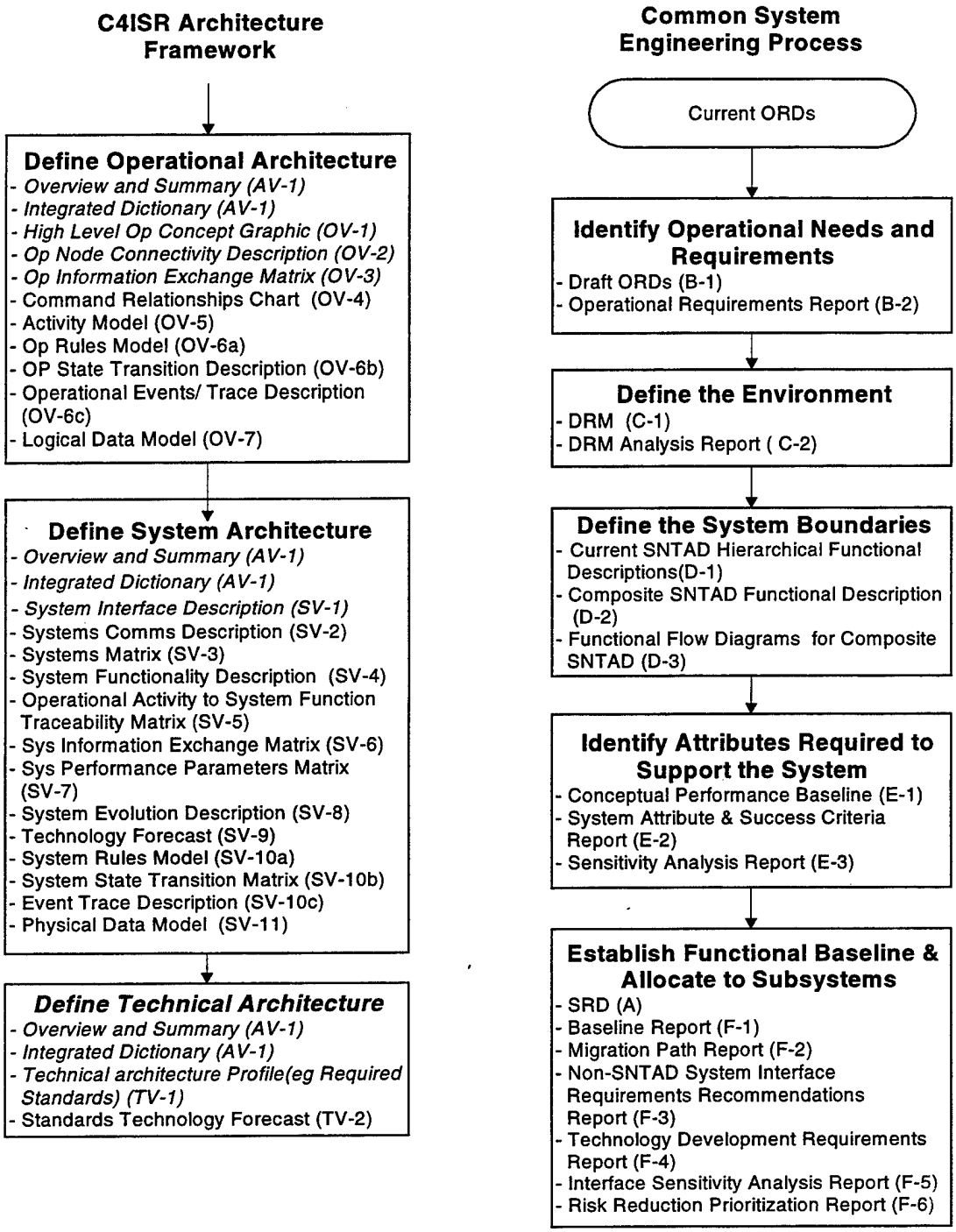



**Figure C-1. Summary of Processes**

**Table C-1. Mapping Of Common Systems Engineering Process Products To Those Called For In The C4ISR Architecture Framework.**

| C4ISR Architecture Framework Products | Corresponding Common Requirements System Engineering Process Products That Contains The Same Or Similar Information |
|---|---|
| (AV-1) Overview and Summary | Similar Information in the SRD |
| (AV-1) Integrated Dictionary | Information Included in the Notes Section of SRD |
| (OV-1)Operational Concept Graphic | Similar Information in the SRD |
| (OV-2) Operational Node Connectivity | Similar Information in (D-3) Functional Flow Diagrams for Composite SNTAD |
| (OV-3) Operational Information Exchange Matrix | Note 1 |
| (OV-4) Command Relationships Chart | Input to Step 1 of the Common Requirements System Engineering Process |
| (OV-5) Activity Model | Similar Information in (D-2 ) Composite SNTAD Functional Description and (D-3) Functional Flow Diagrams for Composite SNTAD |
| (OV-6a) Operational Rules Model | Note 1 |
| (OV-6b) Operational State Transition Description | Note 1 |
| (OV-6c) Operational Events/ Trace Description | Note 1 |
| (OV-7) Logical Data Model | Note 1 |
| (SV-1) System Interface Description | Similar information in the SRD, (F-1) Baseline Report, and (F-3) Non-SNTAD Interface Requirements Recommendations |
| (SV-2) Systems Communications Description | Note 1 |
| (SV-3) Systems Matrix | Information contained in the SRD and (F-1) Baseline Report |
| (SV-4) Systems Functionality Descriptions | Information contained in the SRD and (F-1) Baseline Report |
| SV-5) Operational Activity to System Functions Traceability Matrix | SRD and (F-1) Baseline Report traces functions to operational requirements |
| (SV-6) System Information Exchange Matrix | Note 1 |
| (SV-7) System Performance Parameters Matrix | (F-1) Baseline Report |
| (SV-8) System Evolution Description | (F-2) Migration Path Report |
| (SV-9) System Technology Forecast | (F-4) Technology Development Requirements Report |
| (SV-10a) System Rules Model | Note 1 |
| (SV-10b) Systems State Transition Matrix | Note 1 |
| (SV-10c) Systems Event/Trace Description | Note 1 |
| (SV-11) Physical Data Model | Note 1 |
| (TV-1) Technical Architecture Profile (Required Standards) | Mandatory standards would be identified in the SRD |
| (TV-2) Emerging Standards | N/A |
| **Note 1:** This information would be produced during the development of the systems whose requirements are defined during the Common Requirements System Engineering Process | |

**C4ISR Architecture Framework Overview:**

- The operational architecture view is a description of the tasks and activities, operational elements, and information flows required to accomplish or support a military operation.

  Shows node connectivity and identifies information that must be exchanged between them (referred to as needlines) and the characteristics (substantive content, media, volume required etc.) of that information. Nodes are virtual nodes that reflect operational roles and operational elements, rather than physical nodes. An example of a node would be the Air Operations Commander, or Joint Intelligence Center or a generic SAM Ship. The Operational architecture may include command relationships, operational activity models (similar to a high level functional architecture in conventional system engineering terminology) of the activities performed by each node. The operational architecture also identifies tasks from the Universal Joint Task List (UJTL) that a node performs. Detailed activity sequencing, timing information, operational state transition descriptions, and detailed data descriptions are optional.

- The systems architecture view is a description, including graphics, of systems and interconnections providing for, or supporting, warfighting functions.

  The system architecture view depicts the actual systems and their interfaces assigned to each of the nodes in the operational architecture. The essential architectural information is documented in a system interface description document. It includes internodal, intranodal and intrasystem perspectives. It relates the operational activities and needlines of the operational architecture view to actual systems that will perform these activities.

  Optional information that may be included in the system architectural view include: a functional description for each system, operational activity to system function traceability, matrix of all interfaces for all systems and nodes, details of the information being exchanged, performance parameters for the systems being addressed, modernization plans, technology forecasts, system activity and timing descriptions, state transition diagrams and other detailed system behavior information, and a physical data model. The physical data model would address such items as message format, applicable message standards, file structure etc.

- The technical architecture view is the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements, whose purpose is to ensure that a conformant system satisfies a specified set of requirements.

  At a minimum this architectural view identifies applicable technical standards and states how they are to be applied. It should address such items as operating systems, programming languages, user interface standards, data management standards, data interchange standards, electronic data interchange standards and graphical standards. A standards technology forecast is optional.

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